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UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXIII.[1]

JOHN DONNELL SMITH.

(WITH PLATES X AND XI)

Ouratea Tuerckheimii Donn. Sm. (§ OOCARPAE Engl.)—Folia perelongate oblanceolato-oblonga in quarta parte superiore acutissime acuminata ad basin angustam obtusa praeter quartam partem inferiorem dense argutissimeque mucronato-serrata, venis transversis nervos conjungentibus subtus manfestis. Racemi paniculati folia fere aequantes, pedicellis 1–4-nis alabastra oblongo ovoidea plus minus superantibus. Sepala rigida linearioblonga petalis spatulato-obovatis paulo breviora. Gynophorum ovario vix longius, fructiferum obovoideum drupa globosa paulo minus.

Arbuscula omnino glabrata, ramis et paniculae axibus angulatis. Folia ad apicem versus ramorum 3–4-subverticillata coriacea generis adhuc ex longissimis 36–45^{cm} longa supra medium 8–11^{cm} basi 5–10^{mm} lata, nervis lateralibus crebris arcuatim ascendentibus marginem attingentibus, petiolis crassis canaliculatis 6–12^{mm} longis. Panic ulae pyramidalis rami ascendentes, bracteis scariosis attenuato-lanceolatis 5–7^{mm} longis, pedicellis 10–13^{mm} longis, alabastris 8^{mm} longis, floribus 22^{cm} diametralibus (e schedula Tuerckheimiana Convallariae majalis odorem diffundentibus). Sepala persistentia medio crassiuscula et purpurascentia marginibus scariosa 10^{mm} longa, 3^{mm} lata obtusa, Petala 11–12^{mm} longa 6^{mm} lata. Antherae sessiles 9^{mm} longae. Gynophorum in anthesi 1^{mm} longum pentagonum. Drupa 9^{mm}-diametralis.—Ad *O. gigantophyllam* Engl. foliorum forma magnitudine venis, ad *O. podogynam* Donn. Sm. inflorescentia floribusque accedit.

[1] Continued from BOT. GAZ. 31 : 125. 1901.

In sylvis ad Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350^{m}, Maj. et Sept. 1901, *H. von Tuerckheim*, n. 7829 Pl. Guat. &c., quas edidit Donnell Smith.

EXPLANATION OF PLATE X.—FIG. 1, flowering branch.—FIG. 2, vertical section of flower.—FIG. 3, sepal.—FIG. 4, petal.—FIG. 5, anterior and lateral views of stamen.—FIG. 6, pistil.—FIG. 7, cross section of ovary.—FIG. 8, fruiting branch.—FIG. 9, vertical section of drupe.—FIG. 10, under surface of part of leaf.

Guarea Tuerckheimi C. DC.—Foliis modice petiolatis 5–8-jugis, foliolis oppositis petiolulatis lanceolato-oblongis basi aequilatera acutis apice longiuscule acuminatis acumine obtusiusculo supra glabris subtus ad nervos parce et adpresse pilosulis, paniculis fere e basi 2-partitis ramis inferne breviter ramulosis superne racemiformibus adpresse pilosulis, floribus modice pedicellatis, calyce obtuse 4-dentato petalisque 4 oblongis et apice acutis extus parce et adpresse pilosulis, tubo cylindrico glabro margine leviter crenulato, ovario styloque glabris.

Ramuli juniores adpresse pilosuli dein glabri et pallide fuscescentes lenticellis concoloribus. Folia usque ad 20^{cm} longa. Folia in sicco firmo-membranacea usque ad 15^{cm} longa et ad 5^{cm} lata pellucido-lineolata, nervis secundariis utrinque 8–10 subarcuato subadscendentibus. Rhachis subteres, junior adpresse puberula. Petioluli fere 5^{mm}, petioli 4^{cm}, pedicelli fere 2^{mm} longi. Paniculae florentes fere 16^{cm} longae. Petala in sicco rubescentia 6^{mm} longa 1.5^{mm} lata. Antherae 8 tubi denticulis oppositae infra ½ longitudinis affixae oblongae glabrae vix 1^{mm} longae. Ovarium conoideum gynophorum superans 4-loculare loculis 1-ovulatis. Stigma orbiculare.—Species *G. purpureae* C. DC. in DC. Monogr. Phan. 1: 564 (ubi adde: Peruvia, Pav. in herb. Boiss.) affinis.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Aug. 1901, *von Tuerckheim*, n. 7835 Pl. Guat. &c., qu. ed. Donn. Sm.

Matayba clavelligera Radlk.—Arbor ramis teretiusculis, pilis minutis flavidis pulverulento-tomentellis, lenticellosis; folia abrupte pinnata; foliola 4–6, alternantia vel subopposita, superiora majora obovata, reliqua lanceolato-elliptica, omnia integerrima, petiolulata, membranaceo-chartacea, sicca supra sordide viridia, subtus subfusca, pilis minutissimis obverse clavelliformibus aliisque setulosis plus minus dibrachiatis sparsis glandulisque microscopicis praesertim subtus obsita, ceterum glabra, sparsim

pellucide punctata, hypodermate instructa; paniculae in apice ramorum axillares, elongatae, pulverulento-tomentellae; petala sepalis majora, bisquamata; discus puberulus; fructus turbinatus, 3-lobatus, lobo uno alterove abortu minore, styli reliquiis in stigma breviter divaricato-3-lobum terminatis apiculatus, in stipitem mediocrem loculis breviorem contractus, praeter basin pilis minutis adpressis laxe adspersam glabratus, endocarpio circa seminis insertionem tantum pilosa; semen arillo fere usque ad apicem obtectum.

Arbor ligno duro. Rami paniculas gerentes 4^{mm} crassi, cortice pallide subfusco lenticelloso. Folia circa 25^{cm} longa; foliola superiora $16–20^{cm}$ longa, 7^{cm} latâ, inferiora fere dimidio minora. Paniculae $20–25^{cm}$ longae (ramis apice interdum fasciatis); bracteae bracteolaeque minimae; cymulae subsessiles, subglomeruliformes; pedicelli vix 2^{mm} longi, infra medium articulati, fructigeri 5^{mm} longi. Calycis profunde partiti lobi 1.5^{mm} longi, acuti, extus tomentelli. Petala oblonga, fere 2^{mm} longa, breviter unguiculata squamaeque spathulato-oblongae basi interdum connatae petala ipsa paullulum superantes villosiuscula. Stamina 3^{mm} longa, filiformia, inferne villosa, antherae subglabrae. Fructus vix semimaturus stipite 3^{mm} incluso 1^{cm} longus et latus. — Maxime affinis est *M. floribundae* Radlk. (in Sitzungsber. K. Bayer. Acad. **9**: 626. 1879) foliolis hypodermate instructis et pilis minutissimis obverse clavelliformibus aliisque setulosis plus minus dibrachiatis praesertim subtus obsitis, sed differt foliolis majoribus obovato- vel lanceolato-ellipticis (nec exactius oblongis) et cymulis subsessilibus (nec conspicue stipitatis).

Mazatenango, Guat., Jul. 1867, *Bernouilli et Cairo*, n. 3344.—Cubilquitz, Depart. Alta Verapaz, Guat., Dec. 1900, *von Tuerckheim*, n. 7979 Pl. Guat. &c., qu. ed. Donn. Sm.

SWARTZIA MYRTIFOLIA Sm., var. **Guatemalensis** Donn. Sm.—Folia et superiora et inferiora plerumque simplicia, rarius 3-foliolata, sicut foliolum terminale usque ad 19^{cm} longa 6.5^{cm} lata, petiolo communi late (5^{mm}) alato. Stamina majora 8. Ovarium 6–8-ovulatum.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Maj. 1901, *von Tuerckheim*, n. 7839 Pl. Guat. &c., qu. ed. Donn. Sm.

Gurania megistantha Donn. Sm. (§ F. II. 2. Cogn. in DC. Monogr. Phan. **3**: 680.)—Caulis crassissimus cum pedunculis cirrhisque glaber. Flores masculini maximi racemosi, pedicellis gracilibus glabris. Calycis tubus e basi dilatata longissime cylin-

dricus segmentis attenuato-linearibus 4-plo vel ultra longior. Petala lineari-triangularia subulato-apiculata segmentis calycinis altero tanto fere longiora. Antherae anguste lineares tubi duas partes vel ultra aequantes, appendice lineari-triangulari antherae dimidium subaequante.

Caulis ligneus suberosus digitum crassus e nodis radices aërias fibrillosas longissimas emittens. Cirrhi striati 3–4^{dm} longi. Pedunculi singuli vel bini 7–13^{cm} longi, racemis 2.5–4^{cm} longis, pedicellis 1.4–5^{cm} longis. Calyx miniatus omnino glaberrimus, tubo 3.5^{cm} longo basi 6^{mm}, supra basin 4^{mm} lato, segmentis 8^{mm} longis 1.5^{mm} latis enerviis. Petala utrinque papillosa 15^{mm} longa 3^{mm} lata enervia. Antherae breviter replicatae tubi basin attingentes 20^{mm} longae, connectivo angusto cum loculis glabro, appendice utrinque papillosa. Florum nondum evolutorum tubus 2.5^{cm} longus, segmenta atque conniventia petala 8^{mm} longa, antherae 18^{mm} longae, appendix 8^{mm} longa. Folia, flores feminini, fructus deficiunt.—Haec species, quamvis quot poteram adipisci exempla foliis careant, tamen optime distincta, descriptionem merere videtur.

In silvis Suerrensibus, Llanuras de S. Clara, Cost., alt. 300^{m}, Apr. 1896, *Donn. Sm.*, n. 6649 Pl. Guat. &c., qu. ed. Donn. Sm.—Eandem plantam foliis delapsis legit *Tonduz* in collibus prope Sikúrbete, Talamanca, Cost., Febr. 1895, n. 9385 herb. nat. Cost.

Gonzalea bracteosa Donn. Sm.—Undique plus minus pilosa. Folia oblanceolato- vel obovato-oblonga arcuatim acuminata in basin acutam sensim angustata, stipulis lineari-triangularibus in vaginam petiolo longiorem connatis. Thyrsorum et axillarium et terminalium folia vix aequantium cymae dissitae sessiles brevissimae et cymulae bracteis bracteolisque pluribus foliaceis longissimis involucratae, floribus sessilibus 5-meris. Ovarium biloculare. Bacca globosa calycem aequans.

Frutex 3^{m} altus, caulibus thyrsisque dense appresseque pilosis, novellis et foliis nascentibus canescentibus. Folia supra praeter nervos mox glabrescentia subtus sparsim pilosa et pallidiora 15–21^{cm} longa 4–7^{cm} lata, nervis lateralibus utrinque 7–8, petiolis 5–9^{mm} longis, stipulis persistentibus 1.5–2^{cm} longis, vagina 7–10^{mm} longa. Thyrsi virgati pedunculo 3–7^{cm} longo addito 8–18^{cm} longi, bracteis bracteolisque lineari-lanceolatis vel linearibus 5–12^{mm} longis dense longeque pilosis, cymulis subsessilibus, floribus ternis nondum satis evolutis circa 4^{mm} longis. Calyx sericeus semiglobosus, dentibus triangularibus intus glabris. Corolla infundibularis praeter setulas erectas glabra, lobis intus et faucibus villosis. Ovarium disco superatum, ovulis paucis.

Bacca sucosa nigra 4^{mm} diametralis, pyrenis in utroque loculo 1–3 (omnibus in speciminibus suppetentibus abortu vacuis).

In silvis profundis udisque ad Suerre, Llanuras de S. Clara, Cost., alt 300^{m}, Apr. 1896, *Donn. Sm.*, n. 6583 Pl. Guat. &c., qu. ed. Donn. Sm.

Psychotria polyphlebia Donn. Sm. (Sect. EUPSYCHOTRIA, § BRACTEOSAE Muell. Arg. in Mart. Fl. Bras. VI. V. 313).— Suffrutex humilis simplex ferrugineo-pilosus. Folia oblongo-obovata superne rotundata minutissime cuspidata in petiolum longum attenuata supra glabra et lineolis punctulata subtus pilosa, nervis lateralibus creberrimis supra prominentibus subtus immersis, venis obsoletis. Pedunculi axillares, capitulis obscure rameis multifloris, bracteis exterioribus ad basin ramorum sitis herbaceis oblongo-ovatis, interioribus subaequilongis oblongis. Calyx ovario stipitato superatus. Corollae tubus lobis 5-plo longior. Drupae cocci orbiculares valde compressi.

Caulis e basi radicante ascendens 12–24^{cm} altus superne pilosus, internodiis brevibus. Folia 11–16^{cm}, longa 5–7.5^{cm} lata, nervis lateralibus utrinsecus 25–34 circa 3–5^{mm} inter se distantibus patulis subrectis parallelis sub margine conjungentibus, petiolis dense pilosis 2–6^{cm} longis, stipulis parvis subulato-bifidis deciduis. Pedunculi pilosi 2–3^{cm} longi. Capitula subhemisphaerica 7–12^{mm} alta basi 15–25^{mm} lata, bracteis haud coloratis discretis bracteolisque lineolatis sparsim piliferis, floribus 5-meris bracteolas involucrantes subaequantibus. Calyx denticulatus. Corolla alba extus sparsim pilifera, tubo tenuiter cylindrico in fauces nudas ampliato. Antherae linearioblongae exsertae. Drupae circa 10-aggregatae globosae carnosae coccineae, coccis osseis 7–9^{mm} diametralibus dorso leviter convexo sulcatis facie ventrali subconcava laevibus.

In silvis uliginosis Suerrensibus, Llanuras de S. Clara, Cost., alt. 300^{m}, Apr. 1896, *Donn Sm.*, n. 6854 Pl. Guat. &c., qu. ed. Donn. Sm.— In declivibus silvestribus montis *Tsaki*, Talamanca, Cost., alt. 500^{m}, Apr. 1895, *Tonduz*, n. 9577 herb. nat. Cost.

Cestrum Poasanum Donn. Sm. (Sect. EUCESTRUM, § I. Dun. in DC. Prodr.).—Glabrum. Folia longiuscule petiolata e basi optime rotunda sensim acutissimeque lanceolata subtus pallida, nervis subtus prominulis fuscentibus, lateralibus arcuatim longeque ascendentibus, areolis subtus conspicuis majusculis. Flores paniculati pauci-aggregati, pedicellis vix ullis bracteolatis. Calyx badius, denticulis subulato-apiculatis. Corollae violaceae tubus

subcylindricus et calyce et lobis propriis 5-plo longior. Filamenta breviter adnata ibidem et loco egressus minutissime appendiculato pubescentia.

Frutex 3–4^{m} altus articulatione foliorum nodosus, ramulis subflexuosis. Folia subcoriacea subtus granuloso-punctulata 8–12^{cm} longa 2.5–4^{cm} lata, nervis lateralibus fortioribus utrinsecus 6–8, petiolis 12–15^{mm} longis. Paniculae axillares et terminales folia vix aequantes, floribus ad apicem versus axium secundariorum 3–4-fasciculatis, bracteolis brevissime filiformibus. Calyx tubuloso-campanulatus 4^{mm} altus 2^{mm} latus, dentibus triangularibus. Corollae succulentae tubus tenuis nervosus e basi sursum paulatim ampliatus super ovarium haud constrictus 21^{mm} longus ad fauces 3.5^{mm} latus, lobi patentes utrinque violacei ovati acuti 4^{mm} longi. Genitalia tubo aequilonga. Filamenta e tertia parte superiore tubi libera et glabra, appendice oblonga 0.5^{mm} longa. Discus cupuliformis. Stigma concavo-discoideum. Drupa fusca globoso-ovalis 7^{mm} longa, seminibus 2–10, nonnullis saepius abortivis.—*C. nocturno* L. affine.

In fruticetis apertis declivium montis vulcanici *Poás*, Prov. Alajuela, Cost., alt. 2500^{m}, Mart. 1896, *Donn. Sm.*, n. 6674 Pl. Guat. &c., qu. ed. Donn. Sm.—Eadem planta sub n. 109 Endres in herb. Kew. exstat.

Columnea calcarata Donn. Sm. (§ ORTHOLOMA Benth.).—Glabra. Folia carnosa nitida parum disparia obovata apice ipsa acuminata in petiolum attenuata. Pedunculi solitarii flore 3–4-plo breviores. Calycis obliqui segmenta inaequalia lanceolata dorso valde carinato in pedunculum decurrentia. Corollae declinatae tubus calyce 5-plo longior in calcar productus supra tertiam partem cylindricam paulatim ampliatus, limbo subobliquo, lobis subaequalibus.

Frutex epiphyticus repens ramosus. Cujusque paris folium alterum 4–6^{cm} longum, 2–2.5^{cm} latum, alterum triente minus, nervis lateralibus utrinque 4–5 et venarum reticulis obscuris. Pedunculi 5-carinati 9–12^{mm} longi. Calyx 6^{mm} altus, segmentis utrinque pubescentibus, majoribus 3^{mm} longis. Corollae coccineae tubus calcare 5^{mm} longo addito 33^{mm} longus vix ventricosus, lobi circa 7^{mm} longi. Stamina ad 1^{cm} supra tubi basin affixa et ibidem pubescentia 18–22^{mm} longa basi in vaginam adnatum connatis, antheris subquadratis 2^{mm} latis, loculis late discretis ovalibus 1.5^{mm} longis. Disci glandula solitaria integra ovalis 2^{mm} longa. Ovarium pubescens oblongo-ovoideum 3^{mm} longum, stylo 27^{mm} longo, stigmate stomatomorpho. Fructus desideratur.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Febr. 1900, *von Tuerckheim*, n. 7645 Pl. Guat. &c., qu. ed. Donn. Sm.

Bravaisia grandiflora Donn. Sm.— Praeter inflorescentiam glabrescens. Folia elliptica utrinque acuminata caudato-producta, venis obsoletis. Panicula folia aequans, bracteolis orbicularibus mucronatis. Calyx bracteolis 3-plo longior, segmentis oblongis mucronatis. Corolla violacea maxima calyce 5-plo longior ad tertiam partem lobata, tubo cylindrica supra calycem in limbum infundibularem ampliato, lobis oblongo-obovatis extus pilosis. Antherae triangulari-sagittatae. Ovarium 4-ovulatum.

Frutex, ramulis subtetragonis lenticellatis. Folia subcoriacea subtus densissime lineata ad apicem versus ramulorum 11–12^{cm} longa 4–4.5^{cm} lata in caudam 11–16^{mm} longam acuminata in petiolos 9–13^{mm} longos basi connatos decurrentia. Thyrsi in paniculam trichotoman subcorymbosam 14^{cm} altam foliaceo-bracteatam dispositi, axibus gracilibus, floribus aggregatis sessilibus, terminali bracteis e basi sessili ovata longissime lineari-productis fulto. Calycis segmenta paene sejuncta 9^{mm} longa obtusa cum bracteolis basi connatis subcoriacea apice carinata enervia flavo-pubescentia ciliata. Corolla 4.5^{cm} longa, tubo 10^{mm} longo, limbo 19^{mm} longo, basi 4^{mm} ore 10^{mm} lato, lobis 13^{mm} latis aestivatione sinistrorsum obtegentibus. Stamina basi barbata et dilatata annulo tenui piloso affixa, antheris 4^{mm} longis, loculis inferne mucronatis. Discus parum conspicuus. Ovarium oblongo-ovoideum. Stylus 27^{mm} longus, stigmatis lobo postico obsoleto. Capsula mihi non visa.

In silvis ad Sachichá, Depart. Alta Verapaz, Guat., alt. 1000^{m}, Apr. 1901, *von Tuerckheim*, n. 7924 Pl. Guat. &c., qu. ed. Donn. Sm.

Citharexylum pterocladum Donn. Sm.— Glabrum. Rami alato-quadrangulares. Folia membranacea oblongo-elliptica apice acutiuscula mucrunculata in petiolum attenuata laxe reticulata. Racemi ex axibus superioribus orti et in paniculam amplam dispositi, pedicellis calyce dimidio brevioribus bracteola bis terve longioribus. Calyx truncatus costis apiculatus. Corolla lilacina nervosa, tubo calycem bis superante lobis supra basin dilatatis paulo longiore.

Arbor silvestris, ramis fistulosis digitum minimum crassis, angulorum alis circa 2^{mm} latis, ramulis ultimis compressis. Folia opposita subfalcata 10–15^{cm} longa 3.5–6^{cm} lata supra minutissime atro-punctulata basi subobliqua glandulis 2 oblongis subtus foveolata, nervis purpurascentibus, lateralibus utrinsecus 6–7, petiolis 2–3.5^{cm} longis. Paniculae usque ad 30–40^{cm} altae, racemis erecto-patentibus 8–20^{cm} longis, floribus sparsis, pedicellis 2^{mm} longis, bracteolis subulato-triangularibus. Calyx tubuloso-campanulatus ore pubescens

ceterum glaber. Corollae praeter margines ciliolatos et fauces cano-villosas glabrae tubus 6^{mm} longus, lobi non satis aequales circa 4^{mm} longi basi 2^{mm} superne 3^{mm} lati reticulato-nervosi, 2 exteriores lineis 3 violaceis notati (ex oculatissimi repertoris schedula). Stamina 4 paulo infra fauces inserta subinclusa.—Ab *C. quadrangulari* Jacq. ramorum alis, foliorum retibus, corollae colore atque nervis insigniter differt.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Febr. et Mart. 1901, *von Tuerckheim*, n. 7922 Pl. Guat. &c., qu. ed. Donn. Sm.

ARISTOLOCHIA ARBOREA Linden ex Hook. Bot. Mag. *t. 5295*. (§ GYMNOLOBUS; *Unilabiatae*.)—Fruticosa ramosa, ramis erectis velutino-setosis; petiolis 1^{cm} longis, foliis adultis crassiusculis superne glabrescentibus subtus, praecipue secus nervos, molliter setosis, 34^{cm} longis 10^{cm} latis oblique oblongo-lanceolatis longe acuminatis basi rotundatis 1-nerviis, nervis secundariis remotiusculis arcuatis; foliis junioribus subtus dense ferrugineo-tomentosis; pedunculis aggregatis e trunco suberoso supra terram emergentibus singulis $3–4^{cm}$ longis gracilibus; perianthio $8–9^{cm}$ longo basi tubulato, tubo superne oblique dilatato in limbum latum cordatum acuminatum venoso-bullatum expanso; fauce aperta processu marculiformi crassiusculo stipitato capitato, capite carnuloso, praedita; columna oblonga, antheris linearibus.—*A. maximam* Jacq. quoad habitum refert, foliis, perianthioque valde differt; processu capitato carnuloso e limbo emergente valde insignis.

De hac specie ita in litt. scribit oculatissimus repertor: "Kleiner Waldbaum; Blumen stets am Grunde des Stammes vorbrechend, braun, an der unteren Spitze weiss."

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Jul. 1901, *von Tuerckheim*, n. 7936 Pl. Guat. &c., qu. ed. Donn. Sm.

ARISTOLOCHIA PILOSA H. B. et K., var. **ligulifera** Mast.—A typo, ex confesso, valde variabili differt haecce varietas limbo perianthii ligulis nigrescentibus carnosulis superne dense vestito.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Mart. 1901, *von Tuerckheim*, n. 7768 Pl. Guat. &c., qu. ed. Donn. Sm.

Haecce varietati forsan attribuenda: n. 2668 Bernouilli et Cario, Guatemala; n. 203 Endres, Costa Rica; n. 1271 Kalbreyer, Ocaña; n. 178 Wagner, Panamá, in herb. Monac.

Aristolochia securidata Mast. (§ GYMNOLOBUS: *Unilabiatae*.)

—Setulosa demum glabrescens, petiolis 3–4^{cm} longis, foliis subcoriaceis glabris 12^{cm} longis 7^{cm} latis cordato-oblongis abrupte acuminatis basi bilobis, lobis rotundatis sinu lato separatis, palmatim 5-nerviis, nervo medio crassiore, nervis lateralibus convergentibus arcuatis; perianthio 4^{cm} longo, tubo basi erecto ventricoso 1^{cm} longo, medio infundibuliformi aequilongo in limbum 3–4^{cm} longum hastato-triangularem nervosum producto; columna oblonga, antheris linearibus; stylis 6 oblongis ad margines recurvatis.— Forma perianthii omnino distincta.

Rosario, Llanuras de Santa Clara, Cost., alt. 300^{m}, Jul. 1899, *H. Pittier*, n. 7604 Pl. Guat. &c., qu. ed. Donn. Sm.

Piper calophyllum C. DC.—Foliis modice petiolatis ample ovatis basi aequilatera cordatis apice acuminatis supra ad nervos et subtus ubique hirsutis, nervo centrali paulo ultra ½ longitudinis suae nervos arcuatim adscendentes utrinque 9 mittente quorum infimi utrinque 3 magis approximati, petiolo usque ad limbum vaginante pedunculoque quam petiolus breviore hirsutis, spica florente cylindrica crassa apice mucronata quam folii limbus pluries breviore, bracteae vertice triangulari-truncato glabro, pedicello lato subcucullato utrinque villoso.

Ramuli hirsuti, amentiferi 11^{mm} crassi nodis hand tumidis, collenchymate haud vel parce et sparsius libriformi in fasciculos discretos disposito, fasciculis intramedullaribus permultis 1-seriatis. Limbi in sicco subcoriacei opaci et pellucido-punctulati circiter 29^{cm} longi et 19^{cm} lati. Petioli fere 4.5^{cm}, pedunculi 1^{cm} longi. Spica florens 6.5^{cm} longa et 6^{mm} crassa, mucrone fere 3^{mm} longo. Stamina 4 ovarii basi ima adnata, antheris reniformibus quam filamento multo brevioribus. Ovarium glabrum apice subattenuatum. Stigmata 3 sessilia linearia brevia et recurva. Bacca verisimiliter subtetragona. —Species sectionis *Steffensia* C. DC.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, 1901, *von Tuerckheim*, n. 7959 Pl. Guat. &c., qu. ed. Donn. Sm.

Mollinedia Costaricensis Donn. Sm. (§ APPENDICULATAE Perk.). —Folia utrinque sparsim appresse pilosa rotundo-obovata aut late ovalia abrupte brevissimeque acuminata basi actua supra medium remote minuteque denticulata. Cymae ad apicem versus pedunculi brevis fasciculatae simplices aut rarius breviter thyrsoideae cum perianthiis luteis pilosae. Perianthii ♂ lobi

ovati obtusi, interiores receptaculum vix superantes exterioribus paulo breviores appendice subquadrata dentata instructi, staminibus circa 22–28. Perianthium ♀ ovoideum, lobis triangularibus aequalibus, carpellis numerosissimis hemisphaericis. Drupae globoso-ovales.

Frutex 10–12^{m} (e schedula Pitterian arbuscula, corona depressa), ramulis novellis pilosis. Folia juniora pellucido-punctulata 6.5–10^{cm} longa 5.5–8^{cm} lata, aetate provectiore coriacea praeter nervos glabrescentia usque ad 16^{cm} longa et 10^{cm} lata, nervis fortioribus lateralibus utrinque 5–6, petiolis pilosis 1–1.5^{cm} longis. Cymae axillares et terminales petiolis paulo vel bis longiores bracteolatae, pedunculo 2–8^{mm} longo, axe primario nonnunquam evoluto, axibus secundariis 5–10^{mm} longis, tertiariis trinis quam flores brevioribus. Perianthium ♂ obpyramidale 6^{mm} altum, lobis erecto-patentibus 3–3.5^{mm} longis, receptaculo intus glabro, antheris ovoideis breviter stipitatis, loculis confluentibus. Perianthium ♀ 9^{mm} altum, lobis 1.5^{mm} longis, receptaculo breviter cupuliformi 7^{mm}-diametrali sericeo alveolato, carpellis sericeis circa 48–54, stylo brevi. Drupae subessiles in specimenibus suppetentibus abortione solitariae 1^{cm} longae deraso indumento glabrescentes.—Juxta methodum in Monographia clari Perkins expositam prope *M. Boliviensem* A. DC. collocari debet.

La Emilia, Llanuras de Santa Clara, Cost., alt. 250^{m}, Apr. 1896, *Donn. Sm.*, n. 6760 Pl. Guat. &c., qu. ed. Donn. Sm.—Tuis probe Turrialba, Prov. Cartago, C. R., alt. 620^{m}, Maj. 1897, *Pittier*, n. 11.250 herb. nat. Cost.—In pascuis ad Aragon, Prov. Cartago, C. R., alt. 630^{m}, Jan. 1899, *Pittier*, n. 13.226 herb. nat Cost.—In silvis ad Las Vueltas, Tucurrique, C. R., alt. 650^{m}, Maj. 1899, *Tonduz*, n. 13.365 herb. nat. Cost.

Ocotea Palmana Mez et Donn. Sm.—Foliis rigidiuscule coriaceis, adultis supra praeter nervos primarios plus minus tomentellos glabratis, subtus adpresse tenuiterque tomentellis, latissime obovato-ellipticis, basi late acutis, apice acumine parvo latoque imposito rotundatis, penninervibus, subtus valde prominuloretatis; inflorescentia dense ferrugineo-tomentosa foliis multo breviore; floribus hermaphroditis, dense tomentellis, perianthii tubo 0; filamentis subnullis; staminodiis deficientibus; ovario glabro stylum papillosum crassum subaequante.

Ramuli dense adpresse ferrugineo-tomentelli. *Folia* petiolis plus minus 20^{mm} longis stipitata, plus minus 190^{mm} longa, 110^{mm} lata, supra costis venisque nonnullis immersis laevia, margine plana. *Inflorescentia* subpauciflora, squarrose breviter panniculata; pedicellis plus minus 3^{mm} longis, bracteolis

partim diu persistentibus lingulato-lanceolatis pedicellos superantibus. *Flores* hermaphroditi, 5–6^{mm} longi; limbi segmentis ovato-ellipticis, subacutis. *Filamenta* ser. I, II omnia subnulla, ser. III antheris bene breviora tomentosa glandulis binis magnis pallidis inter stamina ser. exteriorum collocatis praedita. *Antherae* suborbiculares, apice rotundatae, loculis 2 introsim 2 valde lateraliter fere extrorsim dehiscentibus. *Fructus* ignotus.

In sylvis prope La Palma, Cost., alt. 1500^{m}, Nov. 1898, *Tonduz*, n. 7374 Pl. Guat. &c., qu. ed. Donn. Sm. (n. 12652 herb. nat. Cost.).

Obs. Absque dubio Ocoteae Salvini Mez Guatemalensi peraffinis.

Ocotea Quisara Mez et Donn. Sm.— Ramulis apicem versus bene angulatis; foliis chartaceis, glaberrimis, optime ellipticis, basi breviter nunc brevissime acutis apice eleganter acuminatis, penninervibus, subtus tenuiter denseque prominulo-reticulatis; inflorescentia submultiflora, pyramidatim paniculata, minute cinereo-tomentella, foliis multo breviore; floribus hermaphroditis, adpresse tomentellis; perianthii tubo 0; antheris sessilibus, anguste ellipticis, apice rotundatis, papillosis; staminodiis bene evolutis stipiti-formibus; ovario glabro, ellipsoideo.

Ramuli apicem versus minute peradpresseque cano-tomentelli. *Folia* petiolis plus minus 20^{mm} longis, fere usque ad apicem in statu sicco insigniter nigricantibus stipitata, membranaceo-chartacea, paullo nitidula, plus minus 300^{mm} longa, 115^{mm} lata, margine fere plana. *Inflorescentiae* in ramulorum apice e squamarum deciduarum axillis provenientes; pedicellis vix ultra 4^{mm} longis bracteolis deciduis. *Flores* 4^{mm} longi; limbi segmentis ellipticis, rotundatis; antheris connectivo ultra locellos optime per paria superpositos producto apice rotundatis, ser. exteriorum absque dubio introrsis, ser. III basi glandulis binis globosis manifestis praeditis. *Ovarium* stylo crassiuscule cyclindrico subaequilongo, stigmate capitulato. *Fructus* ignotus.

La Concepcion, Llanuras de Santa Clara, Cost., alt. 250^{m}, Febr. 1896, *Donn. Sm.*, n. 6756 Pl. Guat. &c., qu. ed. Donn. Sm.— La Emilia, Llanuras de S. Clara, alt. 1250^{m}, Apr. 1896, *Donn. Sm.*, n. 6751 Pl. cit.—Atirro, Prov. Cartago, C. R., alt. 600^{m}, Apr. 1896, *Donn. Sm.*, n. 6753 Pl. cit.— Sub Sassafrideo (Ocotea) Veraguensi Meissn. distributa.— Incolis *Quisará*.

Obs. Species e pulcherrimis inter *O. Veraguensem et O. dendrodaphnem* intermedia huic propius accedens. Sed folia et textura et magnitudine nec non inflorescentia pluriflora optime paniculata, &c., plane differt.

Trema enantiophylla Donn. Sm.— Folia opposita oblongo-ovata basi rotundata interdum retusa, in ramis floriferis ovato-elliptica acute elongata basi acutiuscula, stipulis in unam intra-

petiolarem connatis, petiolis linea interpetiolari conjunctis. Cymulae in utraque axilla geminae, floribus dioicis. Perianthii segmenta imbricata. Floris masculini ovarium rudimentarium evolutum.

Frutex 4–6^{m} altus, ramis cavis medullosis glabrescentibus rubiginosis verrucosis, novellis pubescentibus. Folia majora 14–16^{cm} longa 8–10^{cm} lata, folia cymulas fulcientia 9–12^{cm} longa 3.5–5^{cm} lata, supra pilis bulbosis scabra subtus glabrescentia tri- vel tripli-nervia, nervis lateralibus utrinque 3–5 et basilaribus angulo acuto alte ascendentibus, petiolis pubescentibus 1.5–5^{cm} longis, stipulis lineari-triangularibus 3–6^{mm} longis. Cymulae pubescentes multiflorae, masculinae 20–25^{mm} longae, femininae 15–18^{mm} longae, pedicellis quam flores brevioribus basi bracteatis, floribus 5-meris. Floris ♂ perianthium 2.5^{mm} altum usque ad basin paene partitum, segmentis erecto-patentibus oblongo-ellipticis obtusis intus glabris, filamentis glabris perianthio paulo brevioribus jam in alabastro erectis, antheris subversatilibus, disco piloso, ovarii rudimento 1^{mm} longo stylo bifido rubescente apiculato. Floris ♀ perianthium minutum campanulare, lobis brevibus ovalibus, staminodiis 0, ovario semi-incluso subobovato 2^{mm} alto leviter compresso, stylo usque ad basin in ramos 2 ovario longiores totos stigmatosos diviso, ovulo pendulo. Fructus mihi non visus.—Species phyllotaxi et stipulis in Tribu *Celtidiae* abnormis Pileam mentitur. Num sit genus novum?

Secus flumen prope Estrella, Prov. Cartago, Cost., alt. 1800^{m}, Mart. 1888, *Juan J. Cooper*, n. 5949 Pl. Guat. &c., qu. ed. Donn. Sm.—Ad ripas Río Pedregoso, El Copey, Cost., alt. 1800^{m}, Febr. 1898, *Ad. Tonduz*, n. 7517^{B} Pl. Guat. &c., qu. ed. Donn. Sm. (n. 11734 herb. nat. Cost.).

Costus splendens Donn. Sm. et Tuerckheim.— Folia glabra petiolata maxima lanceolata e medio utrinque angustata, infima obovato-elliptica. Bracteae inferiores foliaceo-appendiculatae, florales optime ovales floribus maximis bis superatae. Calyx campanulatus quarta parte triangulari-dentatus. Corolla aurea, lobis obtusis. Labellum elongato-obovatum corollam triente superans 3-lobatum, lobis lateralibus sub-quadratis violaceo-purpureo-fasciatis, intermedio in lacinias 3 plus minus angustas recurvas aureas usque ad basin fere partito. Stamen oblongo-ellipticum, apice longe acuteque dentata inflexa.

Caulis biorgyalis et ultra circa 4^{cm} crassus, internodiis plerumque 4–6^{cm} longis, vaginis fere glabris, ocreis pilosis subtruncatis 1^{cm} altis. Folia usque ad 4–5^{dm} longa 12–13^{cm} lata sursum acute attenuata basi petiolo vix latiora, infima 32^{cm} longa 15^{cm} lata, subtus purpurascentia vel denique laete vire-

scentia, petiolis 14^{mm} longis basi dilatata 12^{mm} latis. Spica strobiliformis virescens bracteis 3–4 foliaceis 13–25^{cm} longis fulta, bracteis floralibus extus pubescentibus intus vinosis 5^{cm} longis 2.5^{cm} latis apice rotundatis, bracteola lineari 28^{mm} longa pubescente, floribus generis adhuc maximis circa 1^{dm} longis. Calyx pubescens 10–12^{mm} altus. Corolla glabra 6.5^{cm} longa, tubo 2.5^{cm} longo, segmentis obovato-ellipticis. Labelli lobi circa 20–25^{mm} longi, postici inaequales 22–25^{mm} lati margine erosi, laciniae anticae lineares vel oblanceolate 2–5^{mm} latae. Stamen 3^{cm} longum 13^{mm} latum ultra loculos 12^{mm} longos 17^{mm} productum. Stigma cano-pubescens semiorbiculare 4^{mm} latum, appendice vix breviore ovali bifido. Ovarium dense pilosum late cylindricum 11^{mm} longum.— Foliorum florumque magnitudine, et horum fabrica insignis.

Guatemala, alt. 350^{m}, Jul. 1901, *von Tuerckheim, n. 8015* Pl. Guat. &c., qu. ed. Donn. Sm.

DONNELLIA C. B. Clarke, nov. gen. *Commelinacearum*.— Capsula trivalvis, loculis monospermis; caetera Tradescantiae.

Donnellia grandiflora C. B. Clarke (sp. unica).— *Callisia grandiflora* Donn. Sm. in Bot. Gaz. **31**: 125. 1901.

This species cannot remain in *Callisia*, to which genus Donnell Smith has from the capsule referred it; as he observes, the stamens and the habit are those of *Tradescantia* Sect. *Descantaria*. We may either arrange the plant as a new subgenus *Donnellia* of *Tradescantia*, or call it Donnellia nov. gen., as here proposed. On the suggestion of Captain Donnell Smith, I may here give reasons for this course.

In my monograph of the Commelinaceae (DC. Monogr., Phan. III) no attempt is made to deal with the genera "logically;" the same characters, which in the American genera (*Tradescantia* and its allies) constitute genera, only constitute subgenera in *Commelina* and *Aneilema*. The main reason for this course (*i. e.*, following my predecessors), was to avoid the introduction of new names, and in particular of a disputed synonymy; and Bentham has here followed me; convenience has been preferred to any logical system.

A concrete instance may make this more quickly clear. The two subgenera of *Commelina* are absolutely distinguished (as *cf.* Bentham), and I might have taken up *Monoon* and *Didymoon* as genera (in order to make the arrangement consistent with that of the American group); in this case *Commelina nudiflora* L. would have become *Didymoon nudiflorum* C. B. Clarke, and *Commelina Virginica* L. would have become *Monoon Virginicum* C. B. Clarke. We should then have had two names current for each species; for many botanists would prefer to keep only one genus. But this would have been only a trifling inconvenience. A school of modern botanists, who believe in "laws," hold that the Linnean name *Commelina* must be retained for *something*, must not be sunk altogether. Then would arise the insoluble

problem whether the "type" of the Linnean genus *Commelina* was *some* species of *Didymoon* or *some* species of *Monoon*. Then there would be a question whether he had a type; or, if not, which was the *first* species he regarded as a *Commelina*. We should thus have had one set of botanists adopting the two genera *Commelina* and *Monoon*, another set those of *Didymoon* and *Commelina*, with two new names for each of the ninety species of *Commelina*. The case of DONNELLIA differs; treating it as a genus alters the name of no other existing species.

EXPLANATION OF PLATE XI.—FIG. 1, habit.—FIG. 2, cyme in fruit.—FIG. 3, flower.—FIG. 4, sepal.—FIG. 5, petal.—FIG. 6, perfect stamen.—FIG. 7, imperfect stamen.—FIG. 8, pistil.—FIG. 9, capsule.—FIG. 10, cross section of capsule.—FIG. 11, anterior and posterior views of seed.—*Figs. 1* and *2* are natural size; the others are variously enlarged.

Polypodium Alfari Donn. Sm. (§ EUPOLYPODIUM).—Frons parva pendula glabra pinnata linearis deorsum paulatim attenuata, pinnis utrinque 15–35 adnatis contiguis triangularibus vel e basi triangulari linearibus integris margine superiore ad basin dilatato angulo recto patentibus, inferiore decurrentibus, venis simplicibus paucis brevissimis in pinnarum dimidia parte exteriore nullis, soris 1–6 costae approximatis.

Stipites fasciculati filiforms arcuati castanei inferne pilis patentibus vestiti 1.5–2.5^{cm} longi. Frons membranacea 10–20^{cm} longa 1.5–4^{cm} lata, rhachi ebenea. Pinnae distinctae alternae medio 2–3^{mm} latae, inferiores laxiores, infimae ad alas cuneatas reductae, costa ebenea infra apicem evanescente, vena basali superiore ceteris longiore obsolete sorifera, soris majusculis rotundis, extimis ad costam subimpositis, paraphysibus nullis.—*P. capillari* Desv. proximum.—Oculatissimi repertoris in honorem dicavi.

In truncis arborum, Sierra Alta de Navarro, Prov. Cartago, Cost., alt. 2000^{m}, Maj. 1901, *Anastasio Alfaro*, n. 8063 Pl. Guat. &c., qu. ed. Donn. Sm.

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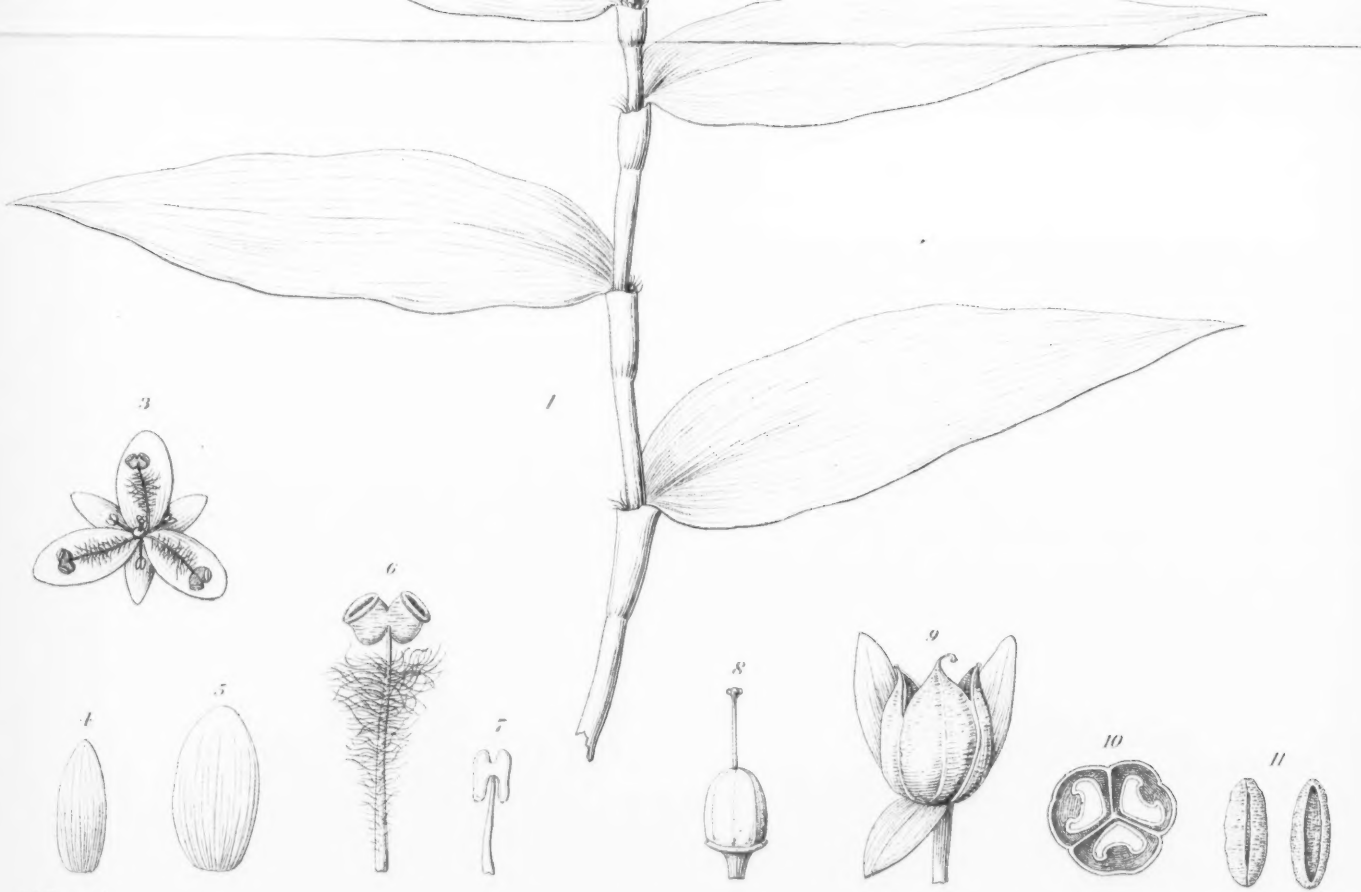
OURATEA TUERCKHEIMII, Donn. Sm.



C.E. Faxon, del.

DONNELLIA GRANDIFLORA, C.B. Clarke.

THE RHEOTROPISM OF ROOTS.

FREDERICK C. NEWCOMBE.

(WITH FIFTEEN FIGURES)

[*Continued from p. 198.*]

II. VELOCITIES EFFICIENT IN THE FORMATION OF CURVES.

IN my published abstract,[1] already referred to, it was stated that definite relations exist between the velocity of flow and the response of the root. Juel[2] paid some attention to the same subject, finding that *Vicia sativa* grew generally with a negative curve, or straight, in velocities above 1800^{cm} per minute; while from that rate down to 1.8^{cm} per minute the response was generally a positive curve. Similarly with *Zea mays* (the variety is not given), the same author found devious behavior in a velocity of 3000^{cm} per minute, but positive curves in a velocity of 1200^{mc} per minute; in velocities of 66^{cm} to 18^{cm} per minute, he found 67 per cent. curved positively; while in velocities of 4.8^{cm} to 1.8^{cm} per minute, less than one-half the roots bent positively. It is clear, therefore, that in a velocity above 1800^{cm} per minute, the primary roots in both species named grow either straight or with a negative bend. As Juel points out, this does not necessarily mean that the roots are either insensitive or negatively rheotropic. They are probably bent negatively or held vertical by the mechanical push of the water. On the other hand, the lower limit of a stimulating current seems to have been approximated for *Zea mays*, but not for *Vicia sativa*, at the rate of 2^{cm} per minute.

My own experiments to determine the limiting velocities inducing response have been carried on with several plants, but

[1] Rheotropism and the relation of response to a stimulus. BOT. GAZ. 22: 242. 1896; Proc. Amer. Ass. Adv. Sci. 1896.

[2] JUEL: Untersuchungen über den Rheotropismus der Wurzeln. Jahrb. Wiss. Bot. 34: 507. 1900.

more extensively with *Zea mays* (popcorn), *Brassica alba*, and *Raphanus sativus*. While the general results could be given in a few words, yet, to afford the reader opportunity to judge the evidence, the following tables are given.

TABLE I.

EXPERIMENTS WITH ZEA MAYS (popcorn). Temperature in air 24°.

No. of experiment and revolutions per minute	Flow per minute	After 9¾ hours	After 18 hours
I 8 seedlings × 40	2500 to 500^{cm}	8 roots = 0°	8 roots = 0°
II 9 seedlings × 26	1630 to 1300^{cm} 1140 to 325	3 roots = 0° 6 roots = +15° to 40°	3 roots = 0° 6 roots = 0
III 8 seedlings × 16	1000^{cm} 900 800 700 600 500 400 300	1 root = 0° 1 root = 0 1 root = 0 1 root = +10 1 root = +20 1 root = +20 1 root = +30 1 root = +40	1 root = −90° 1 root = −45 1 root = 0 1 root = +10 1 root = +25 1 root = +45 1 root = +60 1 root = +90
IV 9 seedlings × 2	125^{cm} 113 100 88 75 62 50 38 25	1 root = +40° 1 root = +45 1 root = +45 1 root = +35 1 root = +40 1 root = +45 1 root = +45 1 root = +45 1 root = +45	1 root = +80° 1 root = +80 1 root = +45 1 root = +80 1 root = +60 1 root = +45 1 root = +50 1 root = +60 1 root = +50

The results recorded in the foregoing table were all obtained with seedlings of the same planting; the experiments were carried on at the same time, at the same temperature, and in the same room. The external conditions, therefore, were as nearly alike as possible.

An examination of my notes on experiments performed at various times during the past three years shows that *Avena sativa* has varied in its response according to the velocity of the flow. Unfortunately, the experiments not being made for the purpose of determining the effect of various velocities, the notes

were not taken in sufficient detail to show more than very general relations. The results are these:

TABLE II.

EXPERIMENTS WITH AVENA SATIVA. Temperature in air 22° to 25°; period for each velocity from 10 to 17 hours, except in the case of 15 roots, where it was 30 hours.

Total no. of roots	Flow per minute	Percentages of curvatures
96	25 to 100cm	46% = +, 51% = 0, 1% = −
57	100 to 300	81 = +, 14 = 0, 5 = −
58	300 to 2000	40 = +, 30 = 0, 30 = −

From this table it is evident that streams with a velocity below 100cm per minute do not bring responses in the majority of individuals; and that velocities of 2000cm and below give many negative curves, these probably being merely mechanical. It is quite probable that velocities above 300cm per minute would give a majority of positive responses, but my notes do not set the approximate upper limit.

The tests with *Brassica alba* show practically the same result as with *Avena sativa*. A velocity above 1000cm per minute will give, so far as my test goes, only vertical and negatively bent roots, while a velocity between 600cm and 1000cm per minute will not bring a positive response in one-third of the roots.

TABLE III.

EXPERIMENTS WITH BRASSICA ALBA, to show upper limit of speed calling forth a response.

Total no. of seedlings	Temperature in air	Period	Flow per minute	Percentage of curvatures
62	22° to 24°	15 to 24 hours	50 to 500cm	87% = +, 13% = 0°, 0% = −
32	22 to 23	14 to 24	600 to 1000	28 = +, 50 = 0, 22 = −
8	23	14	1000 to 2000	0 = +, 50 = 0, 50 = −

The table fails to show the various angles assumed by the roots in various velocities. In the rates between 100cm and 500cm per minute, the angle was in more than half the roots between 60° and 90°. In 56 seedlings tested in a velocity below 100cm per minute, the angle attained averaged less than 40°. In

velocities above 600^{cm} per minute, the angle was less than in the lower rate.

The lowest speed to which any of the roots will respond with well-marked curves has been determined in another series of experiments. The same general method was used as before, except that a klinostat gave the revolution, and no seedlings were set nearer than 3^{cm} to the center of the dish. The seedlings were thus suspended across the diameter of the basin in four groups, two being in the outer circular channel 45^{mm} in radial width, and two being in the inner channel 35^{mm} wide, there being an unoccupied central portion of water 55^{mm} in diameter. The innermost roots that were 3^{cm} from the center were therefore within 5^{mm} of the inner glass wall, and hence it may be assumed that the friction of the water on the glass wall would maintain there a water current with fairly constant direction, even in this slow movement.

In the following table the roots are grouped in two classes—those in the outer channel of the revolving basin where there was a velocity of 2.36^{cm} to 4^{cm} per minute, and those in the inner channel where the velocity was 1.18^{cm} per minute to 2^{cm} per minute.

TABLE IV.

EXPERIMENTS WITH BRASSICA ALBA, to show the lower limit of speed calling forth a response.

EXPERIMENTS	VELOCITIES = 1.18^{cm} TO 2^{cm} PER MIN.						VELOCITIES = 2.30^{cm} TO 4^{cm} PER MIN.					
	No. of seedlings	+ %	o %	− %	Average size of + angles	Extremes of + angles	No. of seedlings	+ %	o %	− %	Average size of + angles	Extremes of + angles
I. 22° C., 23 hrs., × 1 in 16 min.	4 = + 3 = o°	57	43	0	24°	10° to 45°	8 = + 1 = o°	89	11	0	36°	10° to 45°
II. 22° C., 18 hrs., × 1 in 16 min.	4 = + 3 = o° 5 = −	33	25	42	29°	15° to 45°	14 = + 3 = o°	82	18	0	37.5°	10° to 45°
Total	8 = + 6 = o 5 = −	42	32	26	26°	10° to 45°	22 = + 4 = o°	85	15	0	37°	10° to 45°

The foregoing table does not tell the whole story. The roots in the velocities above 2^{cm} per minute had the characteristic appearance of rheotropic responses, the apical part of the root being bent in a curve. The roots in velocities below 2^{cm} per minute showed mere *inclinations* and not curves. Moreover, the bent roots in the higher velocity were in 80 per cent. curved only in a plane parallel with the current, while nearly all the bent roots in the lower velocity were curved either in planes oblique to the direction of the current, or they grew in two or more planes at various angles with one another. In other words, the *velocities below 2^{cm} per minute ceased to control the direction of growth.*

The fact last mentioned is further emphasized by the behavior of the roots of *Brassica alba* in basins of water revolving once in 24 minutes. With such a speed as this, the velocity in the outer channel of the basin extends from 2.50^{cm} to 1.80^{cm} per minute, and in the inner channel from 1.50^{cm} to 0.78^{cm} per minute. The behavior of the roots was about the same in both channels. Seventy-eight roots were used, the temperature being maintained constantly at 22° in air, and the period being 9 hours, 15 hours, 24 hours, and 28 hours in four experiments. Twenty-two roots inclined against the stream, fifteen with the stream, and forty-one roots were neutral. This gives 28 per cent. positive, 19 per cent. negative, and 53 per cent. neutral. But it would be unfair to regard these proportions as of much moment. Rather should it be said that the lower limit of velocity effecting positive responses on the part of these roots has been passed. It cannot be said, however, that the stream is wholly without influence on the direction of growth. Two-thirds of the mustard roots in velocities below 2^{cm} per minute deviated from the vertical direction in their growth. For purposes of summarizing the results given above, all roots bent from the vertical plane in which the seedlings were suspended were counted as either positive or negative, and all roots remaining in this plane were counted as neutral; but many of the roots counted as positive or negative were also oblique to the direc-

tion of the current, and many counted as neutral deviated from a straight course. That this very irregular direction of growth in streams of low speed is due to the movement of water is made known from the fact that these seedlings produce very straight roots in still water. In a control test, fifteen seedlings suspended with their roots in still water grew straight. It seems to be demonstrated, therefore, that currents of water with a velocity less than 2^{cm} per minute are not able to call forth a positive response in the primary root of *Brassica alba*.

The results obtained in attempting to determine the minimum, optimum, and maximum velocities for inducing a rheotropic response in *Raphanus sativus* show that this plant agrees very closely in these respects with *Brassica alba*. Since these results can be most briefly given in tabular form, we will again resort to that method of presentation.

TABLE V.

EXPERIMENTS WITH RAPHANUS SATIVUS, showing relation of response to velocity. Period, 8 to 24 hours, the record being made when the most curves showed in each experiment.

Total seedlings	Temperature in air	Flow per minute	Percentage of curvatures
36	22 to 24°	25 to 100^{cm}	72 % = + 28 % = 0 0 % = −
117	22 to 24	50 to 500	93 = + 3.5 = 0 3.5 = −
24	23	600 to 1000	12.5 = + 87.5 = 0 0 = −
10	22 to 23	1000 to 2000	0 = + 40 = 0 60 = −

From this table it appears that approximately one-fourth of the roots remain neutral in a velocity between 25^{cm} and 100^{cm} per minute, that the optimum speed lies between 50^{cm} and 500^{cm} per minute, and that velocities above 1000^{cm} per minute will not call forth a positive response. This table, however, is not a precise statement of the percentages of response, since some roots curved and straightened again before the final record was made. Such roots were very few in number, and it is not probable that the percentages would be changed more than one or two units if the more accurate record were made.

Not only is the largest number of positive curvatures obtained

in velocities between 50^{cm} and 500^{cm} per minute, but the largest angles also. The most of the curves in velocities below 50^{cm} per minute are less than 30°, while the greatest angles are attained in velocities between 200^{cm} and 500^{cm} per minute.

To determine the effect of a very slow current on the direction of growth of the roots of *Raphanus sativus*, three experiments have been carried out with the revolving water basin, divided as before into three concentric compartments, the roots being immersed in the two outer. The klinostats were adjusted to give one revolution in 32 minutes and one in 45 minutes, offering velocities ranging from 0.4^{cm} to 2^{cm} per minute. No difference in behavior of roots could be detected for the various velocities. The temperature of the air was held constantly at 23°; the period of two experiments was 22 hours, and the other 24 hours. Altogether seventy seedlings were used, giving thirty-four positive inclinations and three negative, while thirty-three roots grew straight.

In the first place, it may be said that the roots of Raphanus are not disturbed, as are those of Brassica, by the very slow currents of water. It will be recalled that two-thirds of the roots of the former grow irregularly in direction, in streams with a current below 2^{cm} per minute. The roots of Raphanus, which are designated above as neutral, pursued a vertical course downward.

In the second place, the fact should be emphasized that in these slow streams the character of the bend of the roots is different from that seen in the higher velocities. In the latter a positive curve is concave toward the stream; in the former the inclination against the stream is either convex toward the stream, or the inclination is in a straight line. In very weak currents, below 2^{cm} per minute, the apex of the root for 2^{mm} or 3^{mm} points vertically downward. The accompanying *fig. 8* will illustrate this difference. The angles attained by the roots of *Raphanus sativus* in these very low velocities ranged from 10° to 45° from the vertical.

Seeing that nearly all the bending roots of the radish are

turned against the stream, we must name the phenomenon positive rheotropism, even in velocities below 1^{cm} per minute. The case is different with the mustard. In that plant velocities below 2^{cm} per minute gave only 28 per cent. of obliquely positive inclinations to 19 per cent. of negative, and 53 per cent. of neutral roots. The difference between the number of positive and negative roots in the mustard is not so great that we may call the excess of 9 per cent. indicative of a positive response. With the radish, however, the roots bend only in a plane parallel with the stream, and thirty-four positive roots to three negative and thirty-three neutral require the verdict that approximately one-half the roots of *Raphanus sativus* are directed by a water stream with velocities ranging from 0.4^{cm} to 2^{cm} per minute, or even by a velocity of less than 1^{cm} per minute.

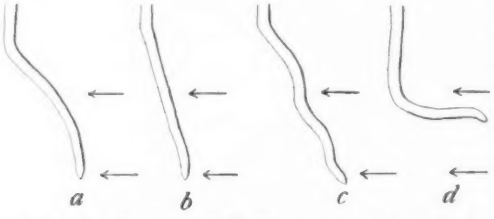


FIG. 8.— Four roots of *Raphanus sativus* after stimulation by the water current. Roots *a*, *b*, and *c* have been in streams with a flow of less than 2^{cm} per minute, while *d* has been in a stream of 200^{cm} per minute.

Helianthus annuus gives mostly positive responses in velocities from 100^{cm} to 600^{cm} per minute; while in one experiment with six seedlings, velocities from 600^{cm} to 2500^{cm} per minute, one root was positive, four negative, and three neutral. *Pisum sativum* in three experiments, with velocities from 500^{cm} to 1400^{cm} per minute, gave nine positive roots, sixteen negative, and nine neutral. From this we may infer that the higher velocities at least cause mechanically negative bends.

Vicia faba gives positive curves in a stronger stream than any other plant worked with. In one experiment, with velocities from 600^{cm} to 2500^{cm} per minute, eight roots bent positively, eight negatively, and three were neutral. In another experiment with six seedlings, two were neutral, while four were positive—one at 1000^{cm} velocity, one at 1500^{cm}, and two at 2000^{cm}.

This is the only plant that has not always given a negative bend in a velocity of 2000^{cm} per minute.

An examination of my notes on all experiments shows that, without having determined the optimum velocity precisely for any species, all of the plants I have worked with give the most constantly positive responses and attain the greatest angles in velocities between 100^{cm} and 500^{cm} per minute.

III. LATENT PERIOD AND AFTER-EFFECT.

A remarkable fact in the rheotropic response of roots is the extraordinarily long latent period. It is true that Berg[3] states that he obtained curves often within thirty minutes. But he gives neither the precise plants, nor temperature, nor velocity with which this result was obtained. When he used the reading microscope in an experiment with *Zea mays*, he found a minimum latent period of one hour. Juel (*l. c.*, p. 529), with *Vicia sativa*, temperature and velocity not given, believed he could detect initial curves in two hours.

My own results agree with those of Berg and Juel, but they have been extended over a larger number of plants, and have brought in also the relation of velocity of current to time of response. The following tables will show how these plants have behaved. Observations were made at the intervals recorded in the tables; and hence the curvatures recorded for any hour, except the first, may have begun between the time recorded and the preceding observation. Close attention failed to reveal any curvature earlier than eighty minutes. Observation was made with the unaided eye, and we may assume, therefore, that the reading microscope would have shown a shorter latent period than eighty minutes. Reference to *fig. 10*, page 275, will convince one that several of those curves must have begun at least ten to fifteen minutes earlier than the time recorded.

The mark "?" in the following table indicates that no observation was made at that time.

[3] BERG: Studien über Rhetropismus. Lunds Universit. Årsskr. 35^{2}: no. 6. 1899.

TABLE VI.

LATENT PERIOD FOR RAPHANUS SATIVUS.

Flow per minute	Temperature in air	Number seedlings	Behavior after 1½ hours	2 hours	2½ hours	3 hours	4 hours	4½ hours	6 hours	7 hours	10 hours	Total no. showing curves within 14 hours
25– 50cm	23°	3	0	0	0	0	0	0	0	0	0	0
60– 100	23	9	0	0	0	0	0	3+	3+	4+	4+	4+
125– 200	23	9	0	2+	2+	3+	3+	3+	5+	?	?	9+
225– 400	23	5	1+	2+	2+	2+	2+	3+	4+	?	?	5+
	26	10	1+	1+	1+	1+	5+	7+				7+
425– 750	23	12	8+	8+	8+	8+	8+	8+	8+	?	?	9+
	26	14	4+	4+	7+	7+	8+	8+				8+
775–1500	23	20	0	0	0	0	0	0	3+	3+	?	7+
1525–2500	23	5	0	0	0	0	0	0	0	0	?	1+

The following table shows the shortest latent period observed for several seedlings. It is certain that the latent period would not be shorter in a velocity either less or greater than that given for each plant, with the exception of that for *Brassica alba*. For this plant, experiment has not shown whether a quicker response would be found in a velocity greater than 250cm per minute.

TABLE VII.

SHOWING SHORTEST LATENT PERIOD OBSERVED FOR SEVERAL PLANTS.

Plants	Optimum temperature for growth [4]	Temperature of air in experiment	Flow per minute	Latent period
Raphanus sativus	——	23°	200–400cm	1⅓ hours
Brassica alba	27.4°	23	200–250	2
Hordeum vulgare	28.7	23	100–225	2
Avena sativa	——	23	100–225	2½
Zea mays (popcorn)	33	24	200–400	3
Pisum sativum	25	23	200–600	3½
Helianthus annuus	31.5	23	150–300	3½
Vicia faba	26.6	25	225–675	6

Lathyrus odoratus responds so slowly that in a set of twenty seedlings in a favorable velocity of water, at a temperature of 20° to 23°, 24 hours elapsed before I was certain that the roots were responding; yet within the next 24 hours fourteen roots showed good rheotropic curves.

[4] These temperatures are taken from the tables in Sachs' *Text-book of Botany*, translated by Vines, 1882, p. 830, but are changed in two cases to accord with results obtained in my own work.

A comparison of the optimum temperature for growth with the temperature used in the experiments will indicate that the seedlings used would probably, in most cases, show in the optimum temperature a shorter latent period than that given.[5] We may suppose that by the aid of the reading microscope the latent period could be seen at the optimum temperature to end for *Raphanus sativus*, *Brassica alba*, and *Hordeum vulgare* in an hour. It is hardly to be supposed, however, that for *Pisum sativum*, *Lathyrus odoratus*, and *Vicia faba*, the latent period could be reduced to two hours. Compared with the latent period in geotropic response, the periods for rheotropism are extremely long. The roots of *Raphanus sativus* when laid horizontally in water, at a temperature of 26°, show to the unaided eye a geotropic bend in 15 minutes; those of *Pisum sativum*, similarly treated, show, at a temperature of 23°, a geotropic bend in 20 minutes. The latent period for rheotropism, therefore, is six times as long as that for geotropism. A rheotropic curve, however, is carried out in opposition to the geotropic tendency of the plant. No one has yet found the latent rheotropic period when gravitation is neutralized. A better comparison can be made with the heliotropic latent period, which is shown by the plant while still under the influence of gravitation.

If seedlings of *Brassica alba* and *Helianthus annuus* have their roots immersed in water in an air temperature of 23°, and are then exposed to one-sided illumination with strong, diffused light, their latent period will be found comparable to that in rheotropism. Four seedlings of *Brassica alba* were used, and the first negative bend perceptible to the naked eye came in 75 minutes. Within two hours of the beginning, all four roots had strong negative curves. The heliotropic curves in Helianthus did not appear until 2½ hours had elapsed; then only three roots out of five had responded.

Tables VI and VII also show the latent period in relation to the velocity of flow. In general, it may be said that for several

[5] CZAPEK (Jahrb. Wiss. Bot. **32**: 195) shows that the optimum temperature for growth gives the quickest geotropic response.

plants the latent period is shortest in velocities between 100^{cm} and 400^{cm} per minute. *Raphanus sativus* and *Vicia faba*, however, have shown their shortest latent period in velocities above 400^{cm} and below 750^{cm} per minute. The influence of velocity on the time of response is shown in a striking way by using the basin of water, revolving at a rate to give critical velocities in the radius, and by suspending a row of seedlings along the radius. From scores of such experiments, two may be selected here. In the first, the revolution was twice to the minute, giving along a radius velocities from 25^{cm} to 125^{cm} per minute. The temperature in water was 22°, and twelve seedlings of *Raphanus sativus* were employed. In two hours the three outermost seedlings had bent +; in three hours the three outermost were +; in four and one-half hours the six outermost were +; and in seven hours the seven outermost were +, while the remaining five nearer the center were all neutral. In the second selection, seedlings of *Brassica alba* were used. The temperature in water was 23°, the revolution 24 times to the minute, and the velocities ranged from 300^{cm} to 1500^{cm} per minute. After three hours the three roots nearest the center of the basin were +; after eight hours the six nearest the center were +; and after fifteen hours the eight nearest the center were +; while the fourteen outermost were all directed vertically downward and therefore to be called neutral.

The foregoing considerations have shown us that the time of response stands in definite relations to the velocity of current. We may at this point inquire whether the variation in the time of response in constant external conditions may be referred wholly to variation in the rate of growth. A seedling is usually regarded as so low an organism among organized beings, that one might expect a low degree of individualization, one might expect constant results in constant conditions of growth and environment. Could we not carry on our experiments in rheotropism quantitatively, and thereby look for constant latent periods and constant angles? The experience of every botanist is against such an assumption. Every one is familiar with the

fact that when several seedlings have their roots laid horizontally so as to carry out the geotropic curve, some roots bend at angles varying from those of the majority, indicating either an individualism in sensitiveness or in response. The rheotropic response shows like variation. In general, the most rapidly growing roots are the first to respond, but in nearly every experiment there are found roots varying their time of response from that of their fellows of equally rapid growth. This fact is illustrated by *figs.* 9 and 10. It is easy to see that root no. 5 has grown most and also curved most; but root no. 2 has grown less and bent more than no. 1, and no. 6 has grown less and bent more than no. 7. It is true that in these cases external conditions were not precisely similar, for the velocity of current for some of the roots was 675^{cm} and for others 725^{cm} per minute, disregarding the irregularities of current caused by the roots themselves. However, root no. 2 was in almost exactly the same theoretical rate of flow as no. 4, must have felt more of the irregularity of flow caused by the roots in front of it than did no. 4, and grew less than no. 4; yet it curved to a greater angle. On the other hand, many of these variations in physiological reaction could probably be reduced were care taken in selecting individuals whose past development and history were known to be similar.

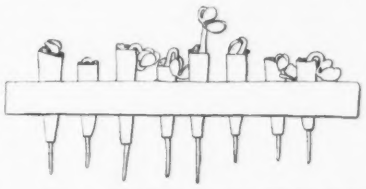


FIG. 9.—*Raphanus sativus*, tracing from a photograph. Seedlings ready for the experiment whose result is shown in *fig.* 10.

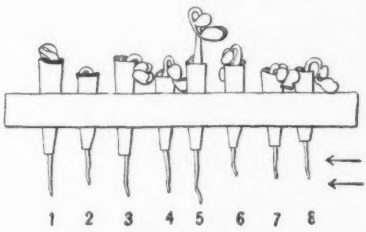


FIG. 10.—*Raphanus sativus*, traced from a photograph taken 1½ hours after placing the roots in a water stream with a temperature of 21°, and a velocity of 675^{cm} to 725^{cm} per minute. To show initial rheotropic curves.

The after-effect of the rheotropic stimulus is shorter than the

rheotropic latent period, both considered without the neutralization of the effect of gravitation. Roots of *Raphanus sativus* rheotropically curved have been seen to begin to straighten geotropically 20 minutes after the water stream was stopped, the temperature in air being 23°. Under similar conditions, except at an air temperature of 28°, the roots of *Zea mays* (*everta*) began to straighten geotropically in 40 minutes. On the other hand, two roots of *Vicia faba*, at a temperature of 25° in air, continued to bend rheotropically for an hour after the water stream was stopped.

From the foregoing results we may conclude that the rheotropic stimulus is in active competition with the geotropic stimulus, so that the operation of the latter is very quickly manifested when the former ceases to operate. One might have supposed the after-effect would have been considerably protracted, seeing that the latent period is so long. Such, however, is not the case. It remains an open question whether the rheotropic latent period would be greatly shortened were the opposing geotropism eliminated. The latent period in this response is no greater than that for traumatropism[6] and that for the clasping of some tendrils.[7]

IV. PERSISTENCE OF SENSITIVENESS.

The response of roots to a stream of water is continuous over a long period; and although there is some evidence to show that roots subjected to a rheotropic stimulus lose in great measure their geotropic sensitiveness, yet we may regard the direction taken by the roots growing in a stream of water as a resultant direction. This resultant direction forms a greater or less angle with the vertical according to the plant species, and according to the intensity of the rheotropic stimulus. This angle may reach 90° in *Fagopyrum esculentum*, *Raphanus sativus*, *Brassica alba*, and other plants, or it may average no more than 45° as in *Vicia faba*, *V. sativa*, *Pisum sativum*, and *Helianthus annuus*. A very weak

[6] SPALDING: On the traumatropic curvature of roots. Annals of Botany 8: 427.

[7] DARWIN: The movements and habits of climbing plants. London. 1875.

stimulus, such as that given by a water current of a few centimeters per minute, gives an average angle in *Brassica alba* and *Raphanus sativus* of perhaps 15°, while the most favorable stimulus brings a response averaging nearly 90°.

It might be thought that a root responding to the rheotropic stimulus by producing an angle of 45° to 90° from its direction of geotropic equilibrium would soon show signs of fatigue by the reduction of this assumed angle. Such behavior, however, on the part of the plant has not been observed, in cases where the stimulus is above a relatively low intensity and below a relatively high mechanical pressure. Thus, ten roots of *Zea mays* (*everta*), in velocities ranging from 50^{cm} to 100^{cm} per minute, all attained an angle of 45° in 11 hours, and maintained the same angle to the end of the experiment, 10.5 hours later. *Helianthus annuus*, with ten roots in water flowing 100^{cm} to 500^{cm} per minute, showed all roots retaining their angle of 90°, 33 hours after the beginning of the experiment, this angle having been attained by most of the roots 15 to 18 hours earlier. Ten seedlings of *Raphanus sativus* (variety Yellow Oval) all bent their roots positively in a velocity of 350^{cm} to 400^{cm} per minute, temperature of water 23°, in a period between twelve and eighteen hours, the exact time not being observed. The angles attained varied from 15° to 90°. Thirty-six hours after beginning the experiment all roots were still positive, and at angles of 30° to 90°. A set of seven seedlings of the Early Long Scarlet radish held their positive angles to the close of the experiment, twenty-nine hours after the angles first appeared.

If the current is very weak many instances have been observed in which a root straightens into its vertical position after an incipient rheotropic curve. Four roots of *Avena sativa* growing in constant current velocities ranging from 50^{cm} to 100^{cm} per minute became positively rheotropic within the first 3¾ hours, but all straightened within the ensuing 1¼ hours. *Brassica alba* in one preparation in a revolving basin where the velocities for the roots ranged from 50^{cm} to 100^{cm} per minute showed six roots positive within three hours, but within the next hour four

of these straightened. *Raphanus sativus*, during the first three hours of an experiment in which twelve seedlings were placed with their roots dipping into water, the velocities at the various distances from the center of the basin ranging from 50^{cm} to 100^{cm} per minute, and the water temperature being 22°, gave rheotropic responses in the three outermost roots. These roots after the lapse of four hours were seen to be straightening. Within the first seven hours of the experiment seven of the twelve roots bent positively, but after seven hours more, all twelve roots, except two tardily straightening ones, were in the vertical position, except for the fixed portions of the rheotropic curves.

Analyzing these results, it would seem that the matter can be thus stated: (1) a rheotropic curve in response to a weak stimulus will, sooner or later, be overcome by the response to gravitation, so that only the geotropic response is evident; (2) a stronger rheotropic stimulus acting at the same time with the normal geotropic stimulus may produce a curve giving a deviation of less than 90° from the vertical, this direction being regarded as a resultant of the water current stimulus and the gravitation stimulus; (3) with highly sensitive roots and a suitable rheotropic stimulus, an angle of 90° from the vertical may be attained, so that the geotropic response of the plant is wholly overcome by the rheotropic, except for the geotropic counter-curve which will be discussed later.

The overcoming of the response to one stimulus by that to another is well illustrated also in the horizontal position taken by stems in response to horizontally directed rays of light, where heliotropism apparently vanquishes geotropism.

V. THE GEOTROPIC COUNTER-CURVE.

One who studies the rheotropic behavior of roots soon notices that when a root has acquired an angle of great deviation from the vertical, the apical 2^{mm} of the root are bent downward, thus forming with the vertical a smaller angle than the part of the root farther back. If, for example, there is a rheotropic curve of 60°, the apex of the root will often show a down-

ward dip of 5° to 40°. This appearance is well illustrated in *fig. 11*.

Both Berg (p. 27) and Juel (p. 529) have discussed this phenomenon, but neither, to my mind, in a very satisfactory manner. The former suggests that the apical 2 mm of the root may not be sensitive to the water stream stimulus, and hence this part does not take the direction of the growing zone, which Berg believes to be sensitive. The objection to the argument of Berg lies in the fact that it is not a question of sensitiveness but a question of response. The receptive tissue and the responsive tissue may be, we know, quite widely separated in various irritable phenomena. Juel explains the S-shaped curve formed by the rheotropic curve and the geotropic counter-curve as resulting from the competition of rheotropism and geotropism, the former being the stronger in the proximal part of the growing zone, and the latter being the stronger in the distal 2 mm.

Before proceeding with the discussion of the S-shaped curve, it may be well to state that it is not peculiar to rheotropism, but is seen also in heliotropism. If seedlings of *Brassica alba* be set up in the usual way with one-sided illumination, I have found when the heliotropic curve reaches or surpasses 45°, that the apical 2 mm show a geotropic counter-curve like that seen in rheotropism. If now, we take into account the experiments of Czapek[8] and Němec[9] showing that geotropic sensitiveness is most likely confined to the apical 1.5 mm to 2 mm of the root, and the experiments of Czapek[10] showing that roots receive their strongest geotropic stimulus when at an angle of 135° above their vertically downward position, and that the effect of the stimulus diminishes constantly with the reduction of this angle, we can readily see that the geotropic downward dip of a rheotropically curved root diminishes greatly the strength of the

[8] CZAPEK: Untersuchungen über Geotropismus. Jahrb. Wiss. Bot. **27**: 243; **35**: 313.

[9] NĚMEC: Ueber die Wahrnehmung des Schwerkraftreizes bei den Pflanzen. Jahrb. Wiss. Bot. **36**: 78.

[10] CZAPEK: Jahrb. Wiss. Bot. **27**: 283.

geotropic stimulus, and thus gives a greater opportunity for the operation of rheotropism. When a root is displaced out of its position of geotropic equilibrium, the angle of ensuing geotropic curvature has been observed by many to begin, according to the diameter of the root, 2^{mm} to 3^{mm} back from the apex. Roots, such as I have used for the most part, are 1.25^{mm} or less in diameter. In these, the geotropic angle is at first about 2^{mm} from the apex; subsequently the curve extends backward, and includes several more proximal millimeters. We may follow the formation of the S-shaped curve thus: The rheotropic curve begins in *Zea mays*, according to Berg, in the $3d^{mm}$ from the apex; and according to Juel in the $3d^{mm}$ of *Vicia sativa*. I have frequently seen it originate in the $2d^{mm}$ of both *Brassica alba* and *Raphanus sativus*, though in these plants it is often first seen in the $3d^{mm}$. Berg's, Juel's, and my own observations agree in noting that the counter-curve generally does not appear till the rheotropic curve has reached an angle approximating 45°. In one set of eight rheotropically curving roots of *Raphanus sativus*, seven had bent to 45° or over, and only one of these showed the dip of the tip. All these observations show that the tip of the root, even the apical 2^{mm}, may take a rheotropic curve. The part of the root farther back begins to curve a little later, and a portion removed as far as 11^{mm} from the apex, may, in *Zea mays*, according to Berg, participate in the rheotropic response. As the rheotropic angle increases, the sensitive apex of the root comes more and more into positions of increasing gravitation stimulus, till finally geotropism overcomes rheotropism, and the geotropic dip begins to appear. As soon, however, as the tip declines, the gravitation stimulus is less strongly felt and the rheotropic angle may now increase. This increase, however, is accomplished by farther bending several millimeters distant from the apex, the tip declining geotropically as the part behind it is lifted rheotropically. This behavior, after the S-curve begins to be formed, really implies a localization of the geotropic response and of the rheotropic response in different parts of the root. This fact is well worthy of special note, for by such initial geotropic curve

the root is enabled to attain to a considerably greater rheotropic and heliotropic angle. The continuance of this behavior brings about a constant straightening of the geotropic curve in its proximal part and a constant re-formation of the geotropic curve in its distal part, giving in a root of *Raphanus sativus* that has been in its rheotropic and geotropic equilibrium for some hours, 2^{mm} to 3^{mm} of the apex dipping to an angle of 45° to 15° from the vertical, back of this apex a straight piece from several to many millimeters in length, generally lying at an angle of 45° to 90° above the vertically downward position, and lastly the rheotropic angle in the form of a more or less open arc connecting the rheotropically growing piece of the root with the older vertical part. *Fig. 11*, drawn from a root of *Lupinus albus*, illustrates the features just described.

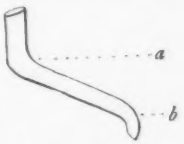


FIG. 11.— Root of *Lupinus albus*, showing (*a*) rheotropic curve and (*b*) geotropic counter-curve.

The rheotropic curve at the beginning may be quite like the geotropic curve of a root, but after some hours it will be noted

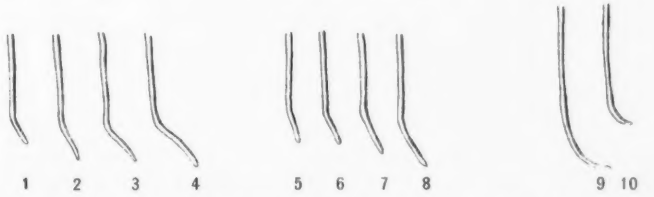


FIG. 12.— Numbers *1* to *4* are tracings of the rheotropic curves of a single seedling of *Raphanus sativus*, during the period of five hours. Numbers *5* to *8* are tracings of another root made at the same time. Numbers *9* and *10* show the geotropic curves of two roots of *Raphanus sativus*. The difference in the character of the rheotropic and the geotropic curves is apparent to the eye.

that the increase of the rheotropic curve is taking place by a bending farther back from the tip than occurs in a geotropic curve. *Fig. 12*, nos. *1* to *8*, shows rheotropic curves of two roots of *Raphanus sativus*, all made at the same time from the same variety and the same planting of seed. The roots

were traced by laying them on ground glass under water, drawing on the ground glass with a lead pencil kept parallel with the roots, then transferring to paper by laying the paper over the ground glass set in a window. *Fig. 12*, nos. *9* and *10*, shows geotropic curves after the plants had been lying horizontally for four hours, with roots in water at a temperature of 23°. The rheotropic curves of *1* to *4* were made in velocities of water ranging from 100^{cm} to 400^{cm} per minute, temperature of water being 22°; and the curves of *5* to *8* were made in similar circumstances except that the velocities ranged from 150^{cm} to 600^{cm} per minute. The early rheotropic curve of 32° at 3^{mm} from the apex in no. *1* continued to increase by farther bending in the same tissue even when this had become 5^{mm} to 6^{mm} distant from the apex, till in no. *4* the angle had become 43°. So also in the roots numbered *5* to *8*, it is evident from the figures that the initial bending of 15° at 3^{mm} from the apex in *5* has in *8* increased to 32° by farther bending in the same tissue, though in the latter case the apex of the angle is 6^{mm} from the root-tip.

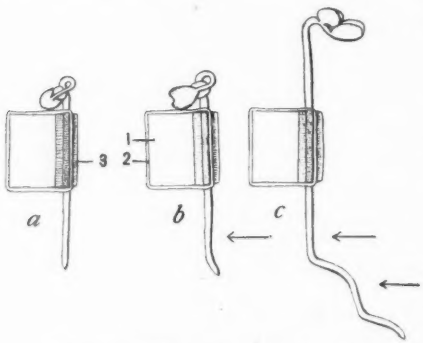


FIG. 13.—*Raphanus sativus*. Three stages of a single seedling illustrating the undulating course of the root; selected from a single preparation of 16 seedlings, 12 of which had similar curves; *a* shows the seedling before beginning the revolution of the basin of water; *b*, after three hours' revolution; *c*, after 21 hours' revolution. The number *1* represents the end of the supporting bar of wood; *2*, the rubber bands holding the two strips of blotting paper (*3*) against the bar of wood. The temperature was 23.5° in water.

A singular result worthy of note is the appearance in a root of several alternating curves of greater and of lesser angle, giving to the root an undulating course. This is well illustrated in *fig. 13*, where a root shows two greater angles and

two lesser. This phenomenon I have seen only in two conditions—in high temperatures when the growth was very rapid, and with a very weak stimulus, the latter illustrated in *fig. 8, c*. It may be explained in either of two ways. We may suppose that the root changes its sensitiveness or degree of response in successive periods of time; or we may suppose that the after-effect of the gravitation stimulus on the one hand, and of the rheotropic stimulus on the other alternately carries the bending root beyond the position of equilibrium, thus producing an oscillation back and forth over the position of equilibrium, the older part of the curving portion being fixed at the two extremes of position, thus producing the undulation observed. That a root may become non-responsive to a water stream after it has already given a rheotropic curve has been shown above. No observations have shown that such a root may in the same current of water show a second response. If, however, a root may regain its sensitiveness or its ability to respond after losing the same, we might expect the appearance of such an undulating course in growth as that just described.

[*To be concluded.*]

A DESCRIPTIVE LIST OF THE PLANTS COLLECTED BY DR. F. E. BLAISDELL AT NOME CITY, ALASKA.

ALICE EASTWOOD.

[*Concluded from p. 213*]

GENTIANACEAE.

133. GENTIANA FRIGIDA Haenke. Jacq. Coll. **2**: 13. Ledeb. Fl. Ross. **3**: 65. DC. Prodr. **9**: 111.—Stems erect, glabrous, 1–1.5^{dm} high: radical leaves linear, connate at base, 1-nerved, 3–6^{cm} long, 2–3^{mm} wide; cauline leaves broad, 1 or 2 pairs, broader and shorter: flowers terminal, 1-3, sessile or on short peduncles, subtended by a pair of leaves: calyx about half as long as the corolla, with the linear-lanceolate divisions shorter than the tube: corolla funnelform, about 4^{cm} long, whitish with greenish-purple dots, the lobes short and broad, sinuate, the plaits broad.

Specimens too young for fruit.

134. GENTIANA GLAUCA Pall. Fl. Ross. **2**: 104. *pl. 93, fig. 2.* 1784–88. Griseb. in Hook. Fl. Bor.-Am. **2**: 58. *pl. 147.*—Stems from slender running rootstocks, glabrous throughout, erect, generally with two pairs of leaves, 6–15^{cm} high, terminated by a few-flowered capitate cyme: leaves obovate to oval, 1–1.5^{cm} long, scabrous on the margins: flowers subtended by a pair of involucral leaves, sessile or on short pedicels: calyx campanulate, 7^{mm} long, with deltoid lobes 2^{mm} long, tapering to the base: corolla 15^{mm} long, acuminate at base, with broadly deltoid obtuse lobes 1.5^{mm} long, the membranous sinus between each either truncate or tipped with a very short lobe: stamens unevenly inserted: ovary on a stipe of almost its own length: capsule exserted beyond the corolla when ripe: seeds invested with a transparent cellular coat which is winged at 2, 3, or 4 angles.

Type locality: "Kamtschatka" ex Ledeb. Fl. Ross **3**: 66.

I am not at all sure that this is *G. glauca*. The foliage is apparently bright green, the filaments are uneven, and the lobes in the sinus of the corolla divisions scarcely apparent.

135. GENTIANA PROPINQUA Richards. App. Frankl. Journ. 734. 1823. Hook. Fl. Bor.-Am. **2**: 62. *pl. 150.*—Root apparently annual: main stem slender, angled, glabrous 5–12^{cm} high, with several more slender and shorter stems or branches from the axils of the radical leaves: leaves in a rosulate tuft at base, narrowly obovate, 1^{cm} long, 4^{mm} wide; cauline leaves ovate, sessile, scabrous on the margins, always with the long-peduncled flowers in their axils: peduncles 1–3^{cm} long, slightly winged especially under the flowers: calyx of two broad ovate-acuminate divisions 5^{mm} long and 2^{mm} broad, and two linear-lanceolate divisions half as broad, scabrous on the margins: divisions of the corolla entire, ovate-acuminate, as long as the swollen tube; glands at base of tube small: stamens inserted below the sinus, the reniform anthers exserted: capsule lanceolate in outline, sessile, 6^{mm} long: seeds oval, brown, 1^{mm} long, minutely papillate.

Type locality: "Cumberland house to Bear lake, and Bear lake river."

CAMPANULACEAE.

136. CAMPANULA LASIOCARPA Cham. Linnaea **4**: 39. 1829.—Stems 2–10^{cm} high, slender, sparingly leafy below, villous: radical leaves lanceolate, narrowed to a petiole, dentate with remote bristly teeth, usually curved; stem leaves linear with the marginal teeth longer: tube of calyx campanulate, half as long as the narrow, acuminate divisions, laciniate-dentate: corolla campanulate, blue, 15^{mm} long, 2^{cm} broad, shortly acuminate, 3-nerved, with broad nerves.

Type locality: "In collibus et montibus Unalascheae."

137. CAMPANULA UNIFLORA L. Sp. Pl. 163. 1753. Fl. Lapp. *pl. 9.*—Stems simple, 1-flowered: radical leaves spatulate to linear-oblanceolate, 5-15^{mm} long: cauline leaves distant, linear-acuminate: flowers small, dark blue: corolla about twice as long

as the subulate divisions of the calyx: tube and divisions of the latter cinereous with white hairs: capsule clavate, 3^{cm} long.

Type range: "in alpibus Lapponicis."

POLEMONIACEAE.

138. POLEMONIUM ACUTIFLORUM Willd. ex Schult. Syst. 4: 792. DC. Prodr. 9: 318.—Stems erect from creeping scaly rootstocks, 2–4^{dm} high, glabrous except for the viscid pubescence of the inflorescence: leaves few, those from the root somewhat larger than the cauline leaves; leaflets 9–24, opposite or alternate, oblong-lanceolate to ovate, mucronate, 3–15^{mm} long, decurrent on the winged rachis; petioles generally shorter than the blades, winged, dilated and sheathing at base, the whole leaf 5–10^{cm} long; stem leaves few and scattered, similar to the radical leaves but smaller, with the petiole woolly-ciliate, especially at base: flowers in a narrow thyrsus or panicle with the peduncles 6^{mm} to 6^{cm} long; bracts usually trifoliate with linear divisions, sessile and clasping; bractlets lanceolate or scale-like, sometimes wanting: calyx campanulate, with the divisions about half the entire length, in flower 4^{mm}, becoming 10^{mm} in age; tube glandular-woolly, thin and membranous between the divisions; divisions of the calyx triangular-subulate, acute or callous-tipped, veiny: corolla rotate-campanulate, with tube very short and divisions obovate; these blue, often darker at base, obovate, acute or obtuse, with margin crisped or entire, ciliate, 12^{mm} long, 8^{mm} wide; tube with a hairy ring 3^{mm} from its base and tufted at the base of the filaments: filaments glabrous, about 8^{mm} long, one-third shorter than the corolla: style but little longer: capsule as long as or sometimes longer than the tube of the calyx: seeds brown, linear-oblong, 4^{mm} long, the body of the seed chestnut-brown with yellow-brown wings at each end.

Type locality: "in Americae borealis plaga occidentali (Pallas)."

In Ledebour *Flora Rossica* 3: 84 this is given as a variety of *P. caeruleum* L. It was collected by Chamisso at Unalashka. Insula Sancti Georgi Promontorium Espenbergii. Sinus Eschscholzii. Insula Chamissonis. ex Linnea 6: 551.

We have no specimens of this for comparison and all the descriptions are so meager as to be quite unsatisfactory; but it is certainly near this if not quite identical.

BORAGINACEAE.

139. **Mertensia Alaskana,** n. sp.—Stems erect, 2–4^{dm} high, leafy with erect leaves appressed to the lower stem, more spreading on the upper, ribbed, glabrous: lower cauline leaves oblong-lanceolate, acuminate, on broad margined petioles about the length of the blade, together 3–8^{cm}; upper leaves sessile, ovate-lanceolate, acuminate, 4–7^{cm} long, revolute, with prominent veins, strigose-pubescent on both surfaces, but more so on the lower, with the short appressed bristles minutely pustulate at base: panicle generally of 3 branches, the lower one solitary, the two upper dichotomous, 2-leaved at base and with a single flower on a deflexed pedicel in the fork; peduncles glabrate, 6–8^{cm} long, naked to the racemose or again panicled flowers; bracts 2, opposite, 15^{mm} long, lanceolate-attenuate; pedicels about 1^{cm} long, sparingly strigose-pubescent, spreading, erect or recurved: calyx divisions subulate, 2^{mm} long, glabrous on the outer surface, minutely hispid on the inner, with ciliate margins: tube of corolla 5^{mm} long, 3^{mm} broad; limb campanulate, 7^{mm} long, almost 1^{cm} in diameter; the rounded lobes 3^{mm} long, 4^{mm} wide; folds in the throat forming a yellow moniliform ring, those at the base of the tube fleshy or bladder-like: stamens on broad margined filaments inserted below the throat; the yellow, narrowly elliptical anthers almost 3^{mm} long, together with half the filament exserted from the throat but included in the limb: nutlets exceeding the sepals, pectinately rugose-tuberculate on the dorsal surface and margins, strongly keeled and rugose on the ventral, loosely investing the seed and firmly attached to the gynobase, very brittle; the scar of attachment near the base; the apices not connivent.

This is included by Dr. Gray under *M. paniculata* Don., Syn. Fl. 2: 201. Specimens sent to Dr. E. L. Greene were identified by him as *M. strigosa*, Pittonia 4: 88. It does not agree with the description of his plant and seems to me to be undescribed.

140. MYOSOTIS SYLVATICA ALPESTRIS Koch. — *M. alpestris* Schmidt, Lehm. Asper. 86. — Caudex branched, from woody rootstocks: stem leafy, simple below the panicle, 10–18^{cm} high, with loose hirsute pubescence: radical leaves oblong-lanceolate, tapering to petioles equaling or longer than the blades, together 2.5–6.5^{cm} long, 5–10^{mm} wide, hirsute and ciliate, obtuse; cauline leaves narrower, oblong, sessile, 1–3^{cm} long: peduncles slender, flowers at first close together, later becoming 3^{cm} apart; pedicels becoming twice as long as the calyx: sepals subulate, 2^{mm} long, white-hirsute: corolla blue, salverform, with tube equaling or surpassing the calyx; limb longer than the tube, with sub-orbicular lobes 2.5^{mm} broad; folds in the throat bilobed; appendages at base 10, globular: stamens inserted on short filaments below the folds; the yellow, elliptical anthers protruding from the throat: nutlets not all maturing, erect, very glossy, attached at the base; scar round; apices somewhat spreading; margined and somewhat keeled on the inner side near the apex.

The specimens at hand vary considerably in size.

141. OMPHALODES NANA Gray Syn. Fl. Suppl. 423. *Myosotis aretioides* Cham. Linnaea **4**: 443. 1829.— Low, depressed-cespitose, forming dense mats with tufted branches to the caudex: leaves sessile, imbricated, forming rosettes, densely white-villous, oblong-elliptical, about 3^{mm} long: peduncles immersed in the leaves, flowers as if sessile: calyx with oblong acute divisions extending to near the base, 1.5^{mm} long, surpassing the tube of the corolla: nutlets with a toothed or spinulose border on the back.

Type locality: "Ad sinum St. Laurentii mixtim cum precedente, meliora quae specimina in insula Sancti Laurentii 1817 collegimus." Chamisso.

SCROPHULARIACEAE.

142. PEDICULARIS CAPITATA Adans. Mem. Soc. Nat. Mosc. **5**: 100.— Perennial from slender running roots: stems scapose or with 1 or 2 leaves below the inflorescence, pubescent with white-woolly hairs: radical leaves on long petioles, once to

twice the length of the blades; these pinnately divided with segments opposite or alternate, ovate, incisely lobed; stem leaves similar but on shorter petioles: flowers capitate; bracts sessile, with oblong, crenate divisions, surpassing the calyx: calyx woolly-pubescent, about as long as the tube of the corolla, enlarging somewhat in age: corolla about 3^{cm} long; lower lip erect, with the lobes not spreading, orbicular, crenulate, woolly-pubescent to the insertion of the stamens, gibbous below the throat; upper lip arching, truncate at tip, about 5^{mm} broad, apparently yellowish-white tinged with rose-color; tube 1^{cm} long: filaments villous at base, inserted 1.5^{mm} above the base, flat with a central rib; anthers purplish, the margins and sagittate bases white: ovary conical, with style 4^{cm} long; stigma capitate: capsule oblique at apex, beaked on one side, exserted from the calyx.

FIG. 6.—Pedicularis capitata. *a*, corolla; *b*, calyx. Nat. size.

143. PEDICULARIS sp.—This is closely related to the preceding, but as there is only one specimen and that not good, I hesitate to name it as a distinct species. The difference in the shape of the flowers can be seen from the figures. It differs from *P. capitata* in the shape of the bracts, calyx, corolla, and in the glabrous filaments.

FIG. 7.—Pedicularis sp. *a*, corolla; *b*, calyx. Nat. size.

144. **Pedicularis hians,** n. sp.—Root slender, woody, branching 1^{cm} below the stem: stems 1–several, 10–15^{cm} high, purple, glabrous and shining below, becoming woolly-pubescent above, clothed at base with brown, imbricated, ovate scales; radical leaves on very slender petioles 2–3 times the length of the pinnatifid blades, glabrous with few very (2^{mm} long) dentate divisions; cauline leaves 2–2.5^{cm} long with broad, linear-lanceolate rhachis twice as broad as the deltoid, entire or dentate, toothlike divisions which extend almost or quite to the base of the

leaf, glabrous except for a few woolly hairs: bracts similar to the cauline leaves, the lower ones surpassing the flowers: flowers capitate, becoming racemose-spicate, on short erect pedicels appressed to the stem: calyx of 5 divisions, the upper one keeled, the 2 lower with the notch between deeper than the others, the 2 side lobes tipped with a crenate-dentate apex, slightly woolly-pubescent: corolla purple with exserted tube, falcately curved galea with the tip blunt and a setaceously acuminate tooth below the apex; lower lip 3-lobed, with orbicular lobes, the middle one smallest, crenate on the margins; throat hairy within, the hairs extending to the tube below: filaments woolly at base and below the anthers; these reddish, tipped with white at the sagittate base: capsule oblique, lanceolate, twice as long as the calyx, cuspidate at apex; style and white tips of anthers exserted.

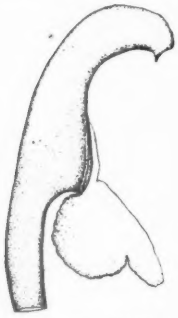


FIG. 8.— Pedicularis hians. × 2½.

This is near *P. Sudetica* Willd., but differs in the shape of the corolla and the form of the leaves.

145. PEDICULARIS HIRSUTA L. Sp. Pl. 609. 1753.— Stems rather stout, about 1.5^{dm} high, clothed at base with the sheathing brown petioles of former leaves: radical leaves with rhachis 1^{mm} broad, divisions numerous, linear, dentate, glabrous, entire leaf 5^{mm} wide, and together with the petiole 5–7^{cm} long; cauline leaves with much broader rhachis and divisions smaller, resembling the snout of a sword-fish, lanate at the dilated bases: inflorescence racemose-spicate, villous-lanate, with erect pedicels about equaling the calyx: calyx campanulate, dentate, ribbed, lanate at apex, 4^{mm} long: corolla with tube a little longer than the galea (8^{mm}), exserted from the calyx; galea about 5^{mm} long, erect, arched, obtuse at apex; lower lip with the lobes almost equal, the middle one concave, erosely crenate

FIG. 9.— Pedicularis hirsuta. × 2½.

on the margin, glabrous within; stamens with 2 filaments glabrous and 2 woolly-pubescent; anthers white, blotched and dotted with brown on the middle: capsule twice as long as the calyx, beaked on one side.

Type range: "in Lapponiae Alpibus."

146. PEDICULARIS LANGSDORFFII Fisch. in Stev. Monogr. in Mem. Soc. Mosc. **6**: 49. *pl. 9. fig. 2.* excl. var. *b.*—Stems low, rather stout, 8–10^{cm} high, clothed at base with broad ovate scales: radical leaves with petioles equaling the blades, together 4–6^{cm} (generally there are some smaller and shorter leaves on very short petioles), pinnatifid with oblong-deltoid divisions, confluent, crenate-dentate near the apex; cauline leaves with the lobes deltoid and generally entire: flowers spicate, but on short appressed pedicels: calyx narrow, 1^{cm} long, 2–3^{mm} wide, conspicuously ribbed, with divisions unequal, linear, foliaceous, some or all crenate near the apex, 3–4^{mm} long: corolla with tube about equaling the galea, exserted from the calyx; galea curved but not falcate, obtuse at apex; lower lip with middle lobe much smaller than the other two: stamens with two filaments woolly and two glabrous: capsule not formed.

Type locality: "in Sibiria Arctica circa ostia Lenae." "Kamtschatka," ex Ledeb. Fl. Ross. **3**: 288.

147. PEDICULARIS LANATA Willd. ex Stev. l. c. 1823.—Similar to the preceding, but the leaves have the divisions more finely lobed and so appear more dissected, the spike is densely lanate and the flowers are smaller: calyx about 5^{mm} long, with obtuse entire divisions half the entire length: corolla with tube equaling the galea; lower lip prominently ridged on the upper surface.

The general form of these two species is the same, the filaments of the last being more densely woolly.

148. PEDICULARIS SUDETICA Willd. Sp. Pl. **3**: 209. no. 13.—Stems 1–several from the root, clothed at base with brown sheaths, glabrous to near the inflorescence, sparsely leaved: radical leaves on broad petioles, longer than the blades, pinnatifid, with divisions linear-oblong, incisely toothed, with white

cartilaginous teeth 3–4^{mm} long; cauline leaves similar but sessile: bracts like the leaves or simple with incised or crenate margins, linear in outline, longer than the calyx: flowers on short pedicels, crowded on a capitate spike that lengthens some with age, woolly-pubescent: calyx shorter than the tube of the corolla, with linear divisions 3^{mm} long, acute, about half as long as the purple, glabrous tube: corolla purple; lower lip with 3 orbicular spreading lobes, the middle one longest but narrowest, erose-crenulate; galea arching a little, longer than the lower lip, with 2 teeth at tip: filaments glabrous: capsule oblique at apex, beaked on one side, exserted from the calyx about 2^{mm}.

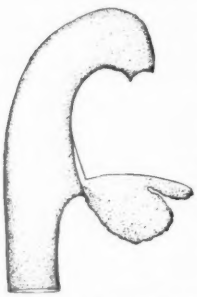


FIG. 10.— Pedicularis Sudetica. × 2½.

Type range: "in montibus Sudetis inque Sibiria."

149. PEDICULARIS VERTICILLATA L. Sp. Pl. 608. 1753.—Stems several from a thick root, 10–15^{cm} high, reddish, woolly-pubescent, leafy with opposite or whorled leaves: leaves petioled, pinnately divided, the oblong divisions with white cartilaginous teeth: flowers purplish, in interrupted, bracteate, whorled spikes: calyx shorter than the tube of the corolla, woolly, veiny, dentate: corolla with galea erect, scarcely arched, with blunt tip, spreading from the 3-lobed lower lip which is longer and several times broader: capsule ovate-acuminate, 1^{cm} long, much exserted.

Type range: "in Sibiria, Helvetia, Austria."

150. VERONICA ALPINA L. Fl. Lapp. *pl. 9. fig. 4.* 1792.—Stems slender, with small, opposite, ovate leaves, entire or sparingly denticulate: flowers small, purplish-blue, in an oblong or capitate spike: fruit emarginate.

The woolly pubescence becomes glandular on the inflorescence and the upper part of the stem. It is apparently abundant.

In the figure referred to above, the stamens and style are exserted beyond the corolla, but in all the specimens at hand they are shorter than the corolla. It seems more like the variety figured in the Bot. Mag. *pl. 2975* under var. *Wormskioldii.*

SELAGINACEAE.

151. LAGOTIS GLAUCA J. Gaertn. Nov. Comm. Petrop. **14**: 533. 1770. *Gymnandra Stelleri* Ch. & Schl. (1827).— Leaves mostly radical, those on the stem bract-like: fruit 2-celled, as in the Scrophulariaceae, but each cell with but one seed: calyx spathe-like: corolla blue, tubular-bilabiate; upper lip entire, lower 2-cleft: stamens 2, inserted in the throat of the corolla, not equaling the style, which is capped with a capitate stigma.

Type localities: "in Siberia inter Lenam et Oceanum (Steller) nos in frigidissimis rupestris ad sinum St. Laurentii collegimus." Chamisso.

This rarely collected plant has the appearance of Synthyris.

LENTIBULARIACEAE.

152. **Pinguicula arctica**, n. sp.— Leaves rosulate, glabrous, apparently fleshy, broadly ovate, sessile, obtuse, 1–2^{cm} long, 5–8^{mm} wide: scape purple, glabrous below, glandular-pubescent above, 1-flowered, 7^{cm} high: calyx 2-lipped; upper lip of 3 deltoid divisions half as long as the lip, the sinus acute; lower lip narrower, with 3 shorter teeth and obtuse sinus one-third as long as the division: corolla purple, 11^{mm} long, hairy within, with club-shaped hairs that extend to the lobes of the upper lip; lobes 3, orbicular, 4^{mm} across; lower lip of 2 similar but shorter lobes; spur slender, tapering, 7^{mm} long: stamens 2, with filaments dilated at base, nearly 2^{mm} long, surmounted by capitate anthers: ovary orbicular, glabrous; stigma of 2 white broad plates, thin in texture.

This appears to be near *P. vulgaris*, but the corolla is of a different shape and hairy within, while the spur is longer.

RUBIACEAE.

153. GALIUM BOREALE L. Sp. Pl. 108. 1753.—This is found throughout the northern hemisphere. The leaves are in whorls of 2 to 4, the tiny white flowers in loose thyrsiform panicles, and the fruits densely hispid.

Type range: "in Europae borealis pratis."

CAPRIFOLIACEAE.

154. LINNAEA BOREALIS L. Sp. Pl. 631. 1753.—The beautiful twin-flower is found throughout the northern hemisphere at high latitudes and in the mountains at subalpine elevations.

Type range: "in Sueciae, Sibiriae, Helvetiae, Canadae sylvis antiquis, muscosis, sterilibus, umbrosis."

VALERIANACEAE.

155. VALERIANA CAPITATA Pall. Link. Jahrb. 1^3: 66. Ledeb. Ic. Fl. Ross. *pl. 346*.—Stems simple, 18–30^{cm} high: lowest stem leaves suborbicular, on broad connate-clasping petioles as long as the blade, together 1–2^{cm} long; second pair of leaves unequally and broadly ovate, 2.5^{cm} long, on similar petioles 5^{mm} long, obscurely denticulate; third pair ovate-acuminate, with narrow lanceolate-acuminate lobes at the sessile base, these lobes one-fifth the length of the main division; nodes hirsute: inflorescence capitate-glomerate; peduncles long, sometimes with two slender branches; involucral leaves of narrowly linear to almost filiform divisions; bracts of the cyme narrowly linear-subulate: corolla white tinged with rose, funnelform, 6–7^{mm} long, one lobe broader than the other three, tube slightly saccate at base: stamens 3, together with the 3-lobed styles exserted: akenes ovate, 3^{mm} long, 1-nerved on one side, 3-nerved on the other.

Type locality: "mont. sabinensibus."

COMPOSITAE.

156. ACHILLEA MILLEFOLIUM L. Sp. Pl. 899. 1753.—Stems erect, 1–3^{dm} high, simple or branched above: leaves bipinnatifid, with the segments pinnately-parted into fine setaceous divisions, lanceolate in outline, 4–9^{cm} long, 5–10^{mm} wide, the lower ones on short petioles dilated at base, the upper sessile: the entire plant white-villous, most densely so at the leaf axils: heads in a broad compound cyme, often with later branches below the main cluster; bracts of the involucre in 3 series, in successive ranks, the linear inner ones narrower and longer than the ovate outer ones, each with the midrib green, keeled, and the border brown

hyaline: rays white, oblong-orbicular, entire 3^{mm} long 2.5^{mm} wide.

Type range: "in Europae pascuis pratisque."

157. ANTENNARIA ALPINA Gaertn. Fruct. **2**: 410. *pl. 167.* 1791.—Heads solitary, with campanulate involucre tomentose at base, above black-brown: involucral scales of the male plant obtuse, denticulate at apex, often emarginate; those of the female plant acuminate: upper leaves terminated by a scarious appendage, the lower mucronate.

This agrees perfectly with the description of Lessing in Linnaea **6**: 221.

158. **Aster arcticus,** n. sp.—Stems low from a slender creeping rootstock, striate, villous below, becoming lanate under the solitary head, leafy, 1–1.5^{dm} high: lowest leaves linear-oblong to narrowly elliptical, sessile, mucronate; upper ones lanceolate, acuminate, short-petiolate, sharply serrate: pubescence on the lower surface rough, appressed; glabrous on the upper: head 2^{cm} in diameter; bracts of involucre equal, lanceolate-acuminate, purple-margined or the inner ones entirely purple, villous, 8^{mm} long, 1–2^{mm} wide: disk corollas purple, glabrous: stamens yellow: style with the appendages hairy at the tips: akenes white-hispid: pappus tawny or the outer purplish.

This is near *Aster prereginus* Pursh, none of the synonyms of which describe it. On sand bars of Nome river.

159. ARNICA OBTUSIFOLIA Less. Linnaea **6**: 236. 1831.—Leaves clustered at the base, oblong, tapering to a broad base, callous denticulate and tipped with a callous point, 3-veined from base to apex, generally also with a shorter vein on each side near the margin, 3–5^{cm} long, 5–10^{mm} wide, glabrous except for the ciliate margins: heads solitary, terminating long penduncles, almost 2^{dm} high, woolly-pubescent: involucral bracts in 2 series, lanceolate, the outer purplish, broader than the green, inner ones 11^{mm} long: rays 10, 3-toothed at apex, ligulate, 15^{mm} long, 3–5^{mm} wide: stamens with black anthers: akenes glabrous: disk corollas with tube hairy and limb glabrous.

Type locality: Unalaschka."

160. ARTEMISIA NORVEGICA Fries, var. PACIFICA Gray Syn. Fl. N. Am. 1: 371.—Stems erect, about 3^{dm} high, glabrous below, villous above: leaves pinnatifid with the divisions incised, the upper 3 confluent, the lowest smallest; petiole of basal leaves equaling the blade, clasping at base; cauline leaves sessile with simpler divisions: heads racemose-paniculate, on long slender peduncles, somewhat secund, nodding at summit: involucral bracts glabrous, dark green margined with brownish-purple, scarious and erose on the margins: disk flowers with perfect akenes.

While this does not agree exactly with the description of the above cited variety it seems best to leave it under that name.

161. ARTEMISIA TILESII Ledeb. Mem. Acad. St. Petersb. 6: 568, ex Linnaea 6: 214. 1831.—Stems erect, 3–4.5^{dm} high, striate, somewhat tomentose: leaves pinnately parted into 3–7 linear-attenuate divisions, the top one much the longest, densely white-tomentose on the lower surface, less so on the upper: bracts linear-attenuate, sometimes with 1 or 2 narrow divisions near the base: heads nodding on erect pedicels in a narrow spiciform thyrsus, more loosely flowered below and taking up half the length of the plant: bracts of the involucre with the middle part greenish, villous, the margin violet-brown, erose: corolla purple or yellow, with glandular tube.

162. CHRYSANTHEMUM INTEGRIFOLIUM Richards App. Frankl. Journ. ed. 2, p. 33. 1823. *Leucanthemum integrifolium* DC. Prodr. 6: 46. 1837.—Stems low, scapose, terminated by a solitary head, 2.5^{cm} in diameter, white-villous, about 8^{cm} high: leaves rosulate, linear, obtuse, entire, 1-nerved, 1^{cm} long: involucral bracts green in the middle and hairy, brown-scarious and erose on the margins, acuminate, 4^{mm} long: rays white, ligulate, obtuse or emarginate at apex, 9^{mm} long, 2^{mm} broad: akenes small, glabrous, without pappus.

163. ERIGERON UNIFLORUS L. Sp. Pl. 864. 1753. Fl. Lapp. *pl. 9. fig. 3.*—Stems about 7^{dm} high, slender, villous with long white hairs: radical leaves spatulate-oblanceolate; cauline linear, villous; the lower ones glabrate: head solitary, 1.5^{cm} in diameter:

involucral bracts linear-attenuate, densely clothed with purple woolly hairs, 5^{mm} long, very narrow: rays purple, filiform, about 50, 4^{mm} long; disk corollas tubular, with 5 purple teeth at summit: pappus barbellate, white: akenes hispid with spreading hairs.

Type range: "in Alpibus Lapponiae, Helvetiae."

164. PETASITES FRIGIDA Fries. Syll. 20. 1854–55. *Tussilago frigida* L. Sp. Pl. 865. 1753.—Leaves deltoid-ovate, deeply cordate at base, irregularly and deeply sinuate-dentate or lobed, the teeth callous-tipped; upper surface almost glabrous, lower white tomentose; petioles equaling or longer than the leaves, together 8^{cm} long: bracts of the flowering stem sheathing, scarious, sometimes foliaceous at apex: female plants with heads in corymbs; bracts of the involucre 1^{cm} long, subulate, a few linear calyculate bractlets at base: akenes linear, glabrous, obtusely ribbed, with loose outer coat: pappus 1.5^{cm} long.

Type range: "in Alpium Lapponiae, Helvetiae, Sibiriae, convallibus."

165. SAUSSUREA ALPINA DC. Prodr. **6**: 535. *Serratula alpina* L. Sp. Pl. 816. 1753.—Stems simple, 5^{cm} to 1.5^{dm} high, ribbed, loosely arachnoid-tomentose: leaves lanceolate, narrowed at base, strongly 1-nerved, loosely tomentose, with margins entire or revolute: heads 1–5; involucral bracts in 4 series, ovate, the outer successively shorter, purple, glandular-hairy; involucre 15^{mm} high: rays none: akenes black, glabrous, with plumose pappus: receptacle with slender chaffy scales among the flowers: corolla with linear divisions to the border, almost equaling the tube, rose-color.

Type range: "In Alpibus Lapponiae, Austriae, Helvetiae, Arvoniae, Sibiriae."

166. SENECIO FRIGIDUS Less. Linnaea **6**: 239. *Cineraria frigida* Richards (1823). Hook. Fl. Bor.-Am. **1**: 334. *pl. 112.* 1840.—Stems simple, 2-flowered, 12–15^{cm} high, glabrous below, clothed with brown floccose wool above: radical leaves oblong, dentate, on petioles nearly twice as long as the blade; lower stem leaves with broadly dilated clasping petioles; upper stem leaves sessile

by a clasping base, sparingly floccose-tomentose, few and diminishing upwards: heads large, terminal, solitary, almost 3^{cm} in diameter; involucral bracts densely clothed with brown wool, linear-oblong, acute, 6^{mm} long: rays about 14, oblong, 3-toothed; disk corollas with campanulate limb, the slender tube longer than the pappus: akenes striate, glabrous.

This may be another species, as it differs in the shape of the disk corollas. The limb in this is more abruptly contracted at base to a more slender and longer tube. In all other respects the two seem identical.

167. SENECIO LUGENS Hook., var. **Blaisdellii**, n. var.—Stems simple, 1.5–2^{dm} high, tomentose: radical leaves lanceolate-oblong, narrowed to a sessile base, denticulate, about 7^{cm} long, 1^{cm} wide (the earliest ones spatulate, much shorter and broader); cauline mostly near the base, narrowly acuminate, dentate below the middle; upper part of stem generally leafless to the inflorescence which is subtended by 1 or 2 leaves: head cymose, 3–5-flowered; pedicels more or less tomentose, the middle one generally half as long as the others; bracts of the inflorescence narrowly linear, black-tipped; involucre campanulate, with a few calyculate bractlets at base; scales oblong, acute, ribbed, tipped with dark purple, 5^{mm} long: rays linear-oblong, 6^{mm} long, 3–4-veined, obtuse or denticulate at apex: style tips truncate, tufted: akenes glabrous, striate.

This is much smaller in all its parts than the typical form as figured by Hooker, and has fewer heads.

168. SENECIO RESEDIFOLIUS Less. Linnaea **6**: 243. 1831.—Stems 1–2 from the base, 6–10^{cm} high: lowest leaves orbicular, crenate-dentate to lyrate-pinnatifid, on broad petioles dilated at base, glabrous or slightly tomentose: upper leaves smaller, sessile, narrowed to a slender acumination: heads solitary, terminating the stem: bracts of the involucre reddish-purple, narrowly linear, obtuse or pointed, 5^{mm} long: rays about 13, orange, 2–3-toothed or cleft, 12^{mm} long, 1.5^{mm} wide: akenes glabrous (very young), with barbellulate pappus: style branches tipped with a cusp surrounded by a tuft of hairs.

Type locality: "In sinu St. Laurentii."

169. SOLIDAGO MULTIRADIATA Ait. Hort. Kew. 3 : 218. 1789. —Stems erect, generally several from a woody rootstock, 2^{dm} high : radical and lowest stem leaves lanceolate-oblong, narrowed to margined petioles, equaling or much exceeding the blades in length, together 2–13^{cm} long, 5–10^{mm} wide, entire or serrate near the apex, veiny, white-woolly-ciliate especially on the petioles ; stem leaves sessile : heads in a round or oblong glomerule, often with some looser and smaller clusters in the axils below : involucral bracts narrowly linear-acuminate, 4^{mm} long, ciliate : rays about 15, narrowly linear, 3–4^{mm} long : akenes pubescent.

Type locality: " Labrador."

170. TARAXACUM OFFICINALE LIVIDUM Koch, ex Gray Syn. Fl. 1 : 440.— Low, acaulescent, glabrous : leaves lyrate-pinnatifid, with petioles exceeding the blades, together 2–5^{cm} long : scape 5–7^{cm} long : involucral bracts turning black in drying ; outer ones ovate, obtuse, slightly ciliate at the apex ; inner longer, linear, with membranous margins : outer rays yellow, with black and white lines down the middle ; inner ones clear yellow, ligulate, toothed at apex, almost 1^{cm} long : heads about 2^{cm} in diameter.

The following species, not included among Dr. Blaisdell's collection, were collected the previous year by Mr. George T. Ruddock at a place near Cape Nome known as Camp Teller : *Ranunculus Pallasii* Schlecht., *Lathyrus maritimus* Bigel., *Conioselinum Gmelini* C. &. R., *Androsace septentrionalis* L., *Castilleia pallida* Kunth, *Mertensia maritima* Don., *Artemisia borealis* Pall., and *Taraxacum Dens-leonis* L. var.

CALIFORNIA ACADEMY OF SCIENCES,
SAN FRANCISCO.

BRIEFER ARTICLES.

HABERLANDT'S NEW ORGAN ON CONOCEPHALUS.[1]

PROFESSOR HABERLANDT'S contribution to the Schwendener *Festschrift* is an argument based upon previously published data,[2] in which he arrives at conclusions of such great importance, if well founded, that further discussion is certainly worth while. Let us begin with a statement of the facts in the case, in which literal quotations are made from the *Festschrift*.

The subject, *Conocephalus ovatus*, is a Javanese liane, with large, leathery leaves. On its upper surface are some hundred "Scharf differenzirte Epithem-Hydathoden mit Wasserspalten." "Bei keiner anderen Pflanze war die nächtliche Wasserausscheidung seitens der Hydathoden so constant und schön zu beobachten, wie bei der in Rede stehenden Liane." In a concrete case, a leaf ejected 26 per cent. of its own weight in water, in one night. When these hydathodes are poisoned, with 1 per cent. alcoholic corrosive sublimate, the excretion of water ceases. The next morning the leaf is dry outside, but there is "Eine oft sehr weitgehende Injection der Durchlüftungsräume mit Wasser." The water gradually disappeared, with active transpiration during the forenoon. This was repeated for three or four days; then there was a new response. "Auf den bepinselten Blatthälften entstanden nämlich zum Ersatze der vergifteten Hydathhoden ganz neue Wasserausscheidungsorgane von wesentlich anderem histologischen Bau und anderer entwicklunggeschichtlicher Herkunft, wie sie im normalen Entwicklungsgange der Pflanzen niemals auftreten." On subsequent mornings, drops were found on these structures, and the intercellular spaces were not injected. "Die neugebildeten Organe waren also vollkommen im Stande, die getödteten Epithem-Hydathoden in ihrer Funktion zu ersetzen."

[1] HABERLANDT, G., Ueber experimentelle Hervorrufung eines neuen Organes bei *Conocephalus ovatus* Tréc. Bot. Untersuchungen S. Schwendener dargebracht. Berlin, 1899.

[2] HABERLANDT, G., Ueber wassersecrnirende und-absorbirende Organe. Sitzber, Ak. Wiss. Wien. 1:55. 1895.

The substitute hydathodes are formed only where trichome clusters have given place to colleters, and the cuticle has been elevated and then split by mucilage. In their formation the tissue first concerned is the parenchyma of the bundle sheath, which enlarges greatly, breaks through the overlying tissues, and finally grows out into "Farblosen Haaren, die pinselförmig auseinander treten." The neighboring palisade parenchyma may share in this formation. The excretion of water is presumed to be, as in normal hydathodes, an active process. "Nachdem sie ungefähr eine Woche lang allnächtlich Wasser ausgeschieden haben, gehen sie allmählich zu Grunde." After their death, the leaf "Lässt auf seiner Unterseite durch Wucherungen der Epidermis und namentlich der darunter befindlichen Wassergewebsschicht zahlreiche ein-und mehrzellige Wasserblasen entstehen."

Haberlandt's argument from these data may be epitomized as follows. The substitute hydathodes are real *organs*, and not accidental structures, or purposeless results of injury to the plant, because they occur in particular places and are strikingly differentiated (the structural argument), and get rid of the plant's excess of water (the physiological argument). They are *new* organs because no similar structure is known on any part of Conocephalus or any related plant. Natural selection cannot have produced them because the occasion for them does not arise in nature; no known natural agent destroys the normal hydathodes, and they remove all the surplus water at the height of the rainy season. And natural selection would have made the substitute hydathodes reasonably permanent, instead of transitory. Summing up, so far, "Ein neues, zweckmässig gebautes und funktionirendes Organ ganz plötzlich, ohne früheres Vorbandensein einer rudimentären Anfangsbildung, ohne Vermittlung von sich allmählich vervollkommnenden Uebergangsstufen, und ohne die geringste Mitwirkung der Naturzüchtung entstehen kann. Bei der Erklärung des Zustandekommens der geschilderten Ersatz-Organe versagt die Selectionstheorie vollkommen ihren Dienst." The inadequacy of the theories of Nägeli and Weismann to explain completely the phenomenon is then shown; but a plausible solution based on them is reached. "Wenn nun auch ein besonderer Anlagenkomplex, eine eigene Determinante für diesen neuen Typus von Hydathoden im Idioplasma unmöglich vorhanden sein kann, so lässt sich doch wahrscheinlich machen, dass die einzelnen Elemente dieses Anlagenkomplexes im Idioplasma vertreten sind. Die Ersatz Hydathoden bestehen in ihren wesentlichsten Theilen aus

haarförmigen Schlauchzellen, denen die Fähigkeit einseitiger Wasserauspressung zukommt; sie verhalten sich also wie Wurzelhaare, die ja gleichfalls im dampfgesättigten Raume nicht selten die Fähigkeit besitzen, kleine Wassertröpfchen auszuscheiden. Nehmen wir nun an, dass in den Zellkernen der Leitparenchym, Palissaden- und Wassergewebszellen, die zu den Schlauchzellen der Ersatz-Hydathoden auswachsen, die idioplasmatische Anlage zur Haarbildung in Kombination mit der Anlage zu der eine einsitige Wasserauspressung ermöglichenden Struktur der Plasmahaut in Aktion tritt-Anlagen die im Idioplasma unserer Pflanze jedenfalls vertreten sind so erscheinen damit wenigstens die wichtigsten Voraussetzungen für die Entstehung der Ersatz-Hydathoden in der Struktur des Idioplasmas von vornherein gegeben."

If I have left any unclearness in Haberlandt's argument the fault is mine; it is not in the original. From the point where the new structure is recognized as a substitute hydathode, formed to relieve the plant of its surplus water, there is no escaping the conclusion that the theory of natural selection is inadequate and faulty. Nor is this all. Haberlandt concludes: "Ob man aber mit Rücksicht darauf, dass jene Entwicklungsvorgänge zur Entstehung eines *zweckmässig* gebauten und funktionirenden Organes führen, welches ganz ausserhalb des Bereiches der Naturzuchtung liegt, das Walten einer 'Entwicklungsintelligenz' annehmen soll, das zu entscheiden ist Sache des rein subjektiven Ermessens und Bedürfnisses jedes einzelnen. Die Naturforschung hat mit derlei metaphysischen Weiterungen nichts zu thun." But if we follow Haberlandt as far as he leads, we must balk sheer, or take the only remaining step of accepting the evidence of a design. And as surely as teleology is the natural enemy of modern science, it is a real concern of scientists whether or not they furnish material for its exponents. It seems to me that if Haberlandt's data admit of an interpretation freer from teleology, and otherwise more in harmony with the behavior of other plants, the more commonplace interpretation will commend itself.

Haberlandt's *dictum* that in judging the character of a new structure, "Nicht bloss die histologische und physiologische Beschaffenheit der sie aufbauenden Elemente, sondern ebenso sehr auch die jeweilige Kombination dieser Elemente in Betracht kommt," is a help to the clearest view of it only when the function does not follow directly from the structure, and when the units of structure are diverse in development. But when the performance of the function follows

obviously from the structure, and when all structural units are evidently formed in response to a common stimulus by a similar course of growth, then the introduction of the combination of elements as a feature distinct from the elements themselves is superfluous and cumbrous. In this case all the structural elements are similar hair-shaped cells, as stated in two quotations above ; that the stimulus to the formation of them all was the excess of water hardly admits of question. Formed from the original cells which do give rise to them, any essentially different arrangement or combination of these elements from that occurring is not conceivable. That is, the existing combination of the histological elements follows from their origin. The intimate connection of the histological and physiological features is constantly emphasized by Haberlandt ; his whole argument involves this, the "Zweckmässigkeit" of the structure. It is possible that the action of the substitute hydathode follows from its structure even more intimately than Haberlandt explains. There is nothing difficult to believe in his supposition that the excretion of water is active on the part of the cells.[3] Such one-sided activity may be manifested in the endodermis or other cells which force water into the xylem of all plants in which there is root pressure. And it would be only an assumption of a power of the epithem, analogous to many familiar correlations. But even this use of normally dormant determinants is not altogether necessary. Haberlandt says, "Auch eine passive Druckfiltration durch die lebenden Zellen der Ersatz-Hydathode ist nicht anzunehmen, da nicht einzusehen wäre, weshalb durch die turgeszirenden Hydathodenkörper das Wasser leichter durchgepresst werden sollte, als durch die lebenden Parenchymscheiden der Gefässbündel." Very thin walls and protoplasmic linings inside them would suggest easy filtration under pressure; these are characters of the oedemata of tomato to be mentioned presently, and presumably of the structures in question on Conocephalus. More important than visible difference in the structure is difference in the turgor. As I have repeatedly shown,[4] the more rapidly cells grow, the less their turgor becomes. In the hypertrophied cells of the substitute hydathode there must be a very much lower osmotic pressure than in the cells from which they grew. The hydrostatic pressure in the tracheides at night exerts an equal force to

[3] Assuming, what is open to suspicion, that normal hydathodes act in this way.

[4] Ueber den Einfluss von Licht und Temperatur auf den Turgor. Halle a. S. 1896.

drive water through the bundle sheath into the intercellular spaces, and through the substitute hydathode into the free air; but the pressure thus exerted is much less in proportion to the osmotic pressure to which the protoplasm is accustomed in the bundle sheath. It might be anticipated then that through the substitute hydathode, where the excess pressure is relatively great, the water would escape.

After what has been said, I think it will be agreed that, given the structure of the substitute hydathodes as it is, there is nothing very surprising or remarkable in their behavior. It remains, then, to show that the structure is essentially similar to such as the same condition produces in many plants. The condition is excess of moisture. The chief characteristic of the structure is great hypertrophy of a group of cells.

Two years before Haberlandt first published his account, a paper appeared by Atkinson[5] on oedema of the tomato. When tomato beds in the forcing house were warmed so that root pressure furnished water faster than it transpired, or when water was forced into branches by connection with a faucet, these oedemata were developed. In my laboratory, Mr. T. C. Johnson caused their formation readily by forcing water into cut branches under a moderate head of mercury. The observations agreed entirely with Atkinson's, whom I therefore quote: "The epidermal cells were very much enlarged, while the chlorophyll bearing cells just beneath, as well as some of the more deeply seated cells, were greatly elongated in a radial direction, and strongly clavate at their outer extremity where this extended beyond the lateral pressure from adjacent tissue. In many cases the epidermal cells quickly separate and slough off. The cells of the affected areas possess exceedingly delicate walls, so that with little disturbance they would collapse. There was little protoplasm in proportion to the size of the cell and a corresponding amount of cell sap." "The increase in the number of cells in such cases," *i. e.*, when there is an increase, "occurs simply by the formation of transverse walls in the elongated cells." Later Atkinson speaks of "stretching of groups of cells to eight to ten times their normal size." The oedemata appear on the veins of the lower surface of the leaf blade (rarely on the upper surface), on the midrib, petiole, and stem. When water is forced into branches it emerges as drops along the edges of the leaves, or elsewhere, if any injury affords an

[5] ATKINSON, G. F., Oedema of the tomato. Rep. Agr. Exp. Stat., Ithaca, N. Y. 1893, pp. 101–128.

opportunity; to some extent the intercellular spaces become charged. In Atkinson's experiments the plants became wet; it probably did not occur to him to look for the extrusion of water from the sounder oedemata. In our experiments, instituted to see if this took place, the oedemata merely became wet when evaporation was prevented; drops of water were not excreted by them, however freely they might be forced out along the margin of the leaf. Evidently, though water can be forced through them, they are passive in the process, and the water escapes the easier way. But Atkinson says that water is set free by the collapse of hypertrophied cells: "The changes brought about by the escape of water from this and adjacent tissues during the warmer parts of the day may be so profound as to cause the leaf to wilt and die."

On the tomato then we have the same abnormal condition which caused the formation of the substitutes hydathodes of Conocephalus, producing structures which are like them in being formed on the veins, and in being formed from a group of cells of various tissues, which become tubular and segment below, and swell up at the free end; without doubt there are other details of resemblance—as in the thin walls and scanty protoplasm. Unquestionably, the two structures are homologous; but on the tomato the oedemata excrete little water, or the loss injures the plant. Their appearance is a pathological phenomenon, whose cause is clear; to seek to discover a purpose for them would be fatuous. Natural selection has provided the plant with responses to many frequently recurring pathological conditions. The ancestors of Conocephalus were always liable to mechanical injuries, and those whose wounds healed had in such cases an advantage; so the final cutting off of the substitute hydathodes by a callus may be ascribed to natural selection. But such exigencies as the loss of the hydathodes must have occurred to Conocephalus practically as rarely as corrosive sublimate entered them. Of course, natural selection is not responsible for the results. On grounds that we cannot yet elucidate well, even in theory, the hydathode responds to the corrosive sublimate by dying, and the leaf responds to the excess of water by the hypertrophy of groups of cells. The relation of cause and effect is equally clear, the details equally mysterious, in the two cases. We should see a purpose in both or neither. If the "Ersatz-Hydathode" admits of construction as evidence of the reign of an "Entwicklungsintelligenz," the fatal action of corrosive sublimate must make us suspect the presence of a power of evil.

Science cannot make a discrimination between the structures on Conocephalus and tomato. Both must be regarded as oedemata, and it is merely incidental that those of Conocephalus temporarily furnish the easiest avenues for the escape of water under pressure. Haberlandt tells us truly that drops of water can be forced out through root hairs. That happens when the root is in the same condition as the Conocephalus leaves. It does not illustrate a "Zweckmässigkeit" on the part of the root hairs. It does not entitle them to be regarded as organs of excretion, emergency hydathodes. But there is only the same ground for calling the Conocephalus oedemata "organs," when they are of incidental temporary utility.

The position of the "substitute hydathodes," which Haberlandt regards as a striking feature, has not been discussd. They must be formed on the veins, because, as in the tomato, the water is most excessive there. And their appearance under old colleters is at the points of least resistance, where the cuticle is already ruptured and the walls have been partly softened. Atkinson says that oedemata on the tomato stem are formed in places where there are already large cells and "their walls are less resistant." If the oedema cells are even more slender in Conocephalus, as the figures would indicate, it is what should be anticipated from the firmer texture of the leaf.

The tomato has so far been used alone to furnish another instance parallel to that of Conocephalus, because it has been well worked out, and is an especially easy subject for such experiments. There are numerous other known illustrations. Haberlandt mentions the fact that Sorauer describes "Pathologische Veränderungen der Laublätter verschiedener Pflanzen, welche mit dem Bau der Ersatz-Hydathoden von Conocephalus eine gewisse Aehnlichkeit besitzen." After remarking the absence of proof that these structures are caused by excess of water (which proof has been given for the tomato), Haberlandt grants that they may be "Analoge Erscheinungen . . . . unvollkommene Ansätze zu einer Selbstregulation, die bei unserer Pflanze ganz unvermittelt in so vollkommener Weise sich einstellt."

Excessive moisture acts in the same way elsewhere than on leaves. Atkinson[6] describes an oedema on apple branches, resultant from excessive pruning and subsequent congestion with water. Their appearance on tomato stems has been mentioned. Ward (cited by

[6] ATKINSON, G. F., Oedema of apple trees. Rep. Agr. Exp. Stat., Ithaca, N. Y., 1893. pp. 305–307.

Atkinson) has reported them on potato stems. Devaux[7] describes oedemata on potato tubers kept saturated; they naturally appeared where the resistance to their growth was least — at the lenticels. Tubeuf[8] has reported what is doubtless the same result of excessive moisture on trees. They may also occur on roots in water.[9] Von Mohl[10] describes such structures formed under the influence of moisture from the lenticels and cortical parenchyma of *Salix viminalis* branches.

In plants whose normal habitat is wet, there has been an opportunity for natural selection to develop and utilize the excessive growth of the cells under the influence of water; and the utilization has been in several ways. The most common of these adaptations is aerenchyma.[11, 12] The oedemata of the lenticels of stems serve to connect perfectly the normal aerenchyma of water plants with the oedemata of leaves. It is a matter for individual judgment when it should be regarded as in the nature of a disease, and when as a normal structure. Even in water plants (Goebel *et al.*) its formation depends on the moisture and can be artificially regulated. It is not unusual for structures pathological in one plant to be normal in another. But no structure can be regarded as normal on a plant where it occurs too rarely for it to be subject to development by natural selection.

Goebel seems entirely justified in deriving the excessively light and porous tissue of Aeschynomene and other plants in water from aerenchyma. In these this tissue serves as a float. It is formed in the leaf of *Desmanthus* (*Neptunia*) *natans*, the petiole of the water hyacinth (Eichhornia), the stem of Nesaea,[13] and the root of Sesbania.[14] The

[7] DEVAUX, H., Hypertrophie des lenticelles chez la pomme de terre et quelques autres plantes. B. S. B. France. **38**: 48–50. 1891.

[8] TUBEUF, C. v., Ueber Lenticellen-Wucherungen (Aerenchym) an Holzgewächsen. Forst.-Naturw. Zeits. 405–414. 1898; Rev. in Bot. Centralb. **77**: 369.

[9] SCHRENK, H. v., Oedema in roots of *Salix nigra*. BOT. GAZ. **24**: 52. 1897.

[10] Verm. Schriften 259–332. Flora, 1832.

[11] SCHENK, H., Ueber das Aerenchyma, ein dem Kork homologes Gewebe bei Sumpfpflanzen. Jahrb. Wiss. Bot. **20**: 526–574. 1889.

[12] GOEBEL, K., Pflanzenbiologische Schilderungen II. 2. Die Wasserpflanzen. Marburg. 1893, p. 256 ff. *Fig. 69* is abnormal aerenchyma (oedema) in the lenticels, of *Populus nigra*.

[13] SCHRENK, J., On the floating tissue of *Nesaea verticillata*. Bull. Torr. Bot. Club. **16**: 315. 1889.

[14] SCOTT, D. H. and WAGER, H., On the floating roots of *Sesbania aculeata* Pers. Annals of Botany **1**: 307–314. 1888.

water acts on as various tissues to form these floats as are hypertrophied by it in oedemata.

I have not intended to cite any large part of the literature on this subject. For a fuller review of it Sorauer's *Pathology* and the work of Atkinson, Goebel, and Schenk referred to here should be consulted. The cases cited here are sufficient to show that excessive moisture produces on various parts of a great many plants structures essentially similar to those it causes on the leaf of Conocephalus.

A long list of cases similar to this is contained in a more recent paper by Sorauer,[15] in which he comes to the same conclusion with regard to Conocephalus that I have reached independently. Another very recent piece of work is by Miss Dale,[16] who finds that if other conditions are suitable moisture stimulates the formation of "hypertrophied outgrowths of epidermal cells, beginning at a stoma;" sometimes the underlying cells are also influenced. Her description and figure would fit almost perfectly for the raised stoma at the base of the hypocotol of Lupinus (BOT. GAZ. **31**: 413). From the fact that the same conditions of moisture which determine their development at the base of the hypocotyl (where the environment is normally very moist, or the seed would not germinate) do not give rise to them elsewhere on Lupinus, it seems likely that they are a product of natural selection and have a function — probably the increase in gas exchange with the air in or very near the ground. Miss Dale satisfies herself that the Hibiscus intumescences are pathological, but then looks for a function for them, suggesting that "they may be a sort of abnormal organ for the direct excretion of water." But they do not seem to have been observed to excrete it. From her results with Hibiscus and Ipomoea, she suggests that the "Wasserblasen" of Haberlandt's subject occurred on the nether surface of the leaf because the stomata are there.— EDWIN BINGHAM COPELAND, *Hull Botanical Laboratory, Chicago.*

[15] SORAUER, P., Ueber Intumescenzen. Ber. Deutsch. Bot. Gesell. **17**: 456–460. 1899.

[16] DALE, ELIZABETH, Investigations on the abnormal outgrowths or intumescences on *Hibiscus vitifolius* L. Phil. Trans. Roy. Soc. London. Bot. **194**: 163–182. 1901; also a note in Bot. Centralb. **85**: 372–375. 1901.

CURRENT LITERATURE.

BOOK REVIEWS.

Agricultural bacteriology.

WITHIN THE LAST DECADE great activity has been shown in bacteriological research along agricultural lines. The medical phase of the subject has controlled the major part of investigation so long that it has escaped the attention of many that in its other applications bacteriology is destined to exercise an important influence. Professor Conn[1] has certainly performed an important service by bringing together in popular form the results of these numerous investigations that bear on the different phases of agriculture. A perusal of these pages will indicate that the subject of agricultural bacteriology is indeed a broad one.

Part I includes a summary statement as to the nature of bacteria, and especially as to the principles of fermentation, that process which is of such far reaching importance in agriculture. Part II embraces a discussion of soil problems, as to the origin of soil and transformation which carbon and nitrogen undergo as a result of bacterial activity. The action of bacteria in dairy processes is considered in Part III, a phase of the subject which often receives special treatment under the head of dairy bacteriology. The various technical fermentations that occur in the formation of vinegar, tobacco curing, silage, and sugar industry comprise Part IV; while the principles involved in the various methods of preserving food products are discussed in Part V. The relation of disease bacteria as noted in maladies of farm animals is included in Part VI.

In a number of these processes, the previously accepted view that bacteria are the sole cause of the fermentative changes has been modified materially by the study of enzyme action that must be ascribed to other than bacterial sources. Professor Conn has included a discussion of these researches, even though their non-bacterial nature has been demonstrated. This broadens the scope of the book and at the same time greatly increases its value. The book is written in a pleasing, vigorous style that is designed primarily for the general reader. At the end of each part a brief bibliography is appended that will be helpful to students who wish fuller data as to the literature.— H. L. RUSSELL.

[1] CONN, H. W., Agricultural bacteriology. 8vo. pp. 412. Philadelphia: P. Blakiston's Son & Co. 1901.

Practical botany.

A FOURTH EDITION of Professor Strasburger's[2] well-known *Das kleine botanische Practicum* has just appeared and, like the previous editions, it is remarkable for the judicious manner in which the presentation of fundamental subject-matter is flavored with modern research. As before, there are thirty-two chapters, and the general method of presentation, which has proved successful, has been retained, so that a glance at the table of contents might lead one to imagine that little change has been made. An examination of the exercises, however, shows that the entire work has been carefully revised, that examples have been changed, and that every effort has been made to bring the book up to the present standpoint of botanical science. The number of forms studied has been somewhat reduced, on the ground that it is better to study a smaller number of forms thoroughly than a larger number superficially. A few of the improvements to which special attention might be called are as follows: a study of sensitive hairs and papillae, a study of double fertilization, a more extended study of protoplasmic connections with the latest methods of demonstrating them, and a particularly thorough revision of the chapters on bacteria and on cell and nuclear division. A large number of new figures has been added.

It may not be out of place in this connection to call attention to a book[3] which might be mistaken by the general student for an English translation of Professor Strasburger's work. In the first edition of the translation the translator added some notes of his own and also some additional illustrations, but all such matter was clearly indicated by brackets. In the second edition many of the brackets were eliminated, and in the last edition all brackets have been removed and the translator's notes incorporated into the text, so that it is difficult, and, for one who really needs a translation, impossible to distinguish what rests upon Strasburger's authority from that which has been inserted by the translator. Several figures have also been substituted. This is, to say the least, unfortunate, since in all of the German editions stress has been laid upon the fact that Professor Strasburger has drawn all the figures, and that all statements, even when they concern matters of common knowledge, rest upon his own investigations. Some of the statements, *e. g.*, referring to Cladophora as non-cellular, are directly contrary to Professor

[2] STRASBURGER, E., Das kleine botanische Practicum für Anfänger. Anleitung zum Selbststudium der mikroskopischen Botanik und Einführung in die mikroskopischen Technik. Vierte umgearbeitete Auflage. 8vo, viii+251, with 128 figures. Jena: Gustav Fischer. 1902. *M* 6.

[3] *Handbook of Practical Botany* for the laboratory and the private student, by Dr. E. Strasburger. Translated and edited from the German with many additional notes by W. Hillhouse. 5th ed., rewritten and enlarged. 8vo. xxxii+519. London: Swan Sonnenschein & Co. 1900.

Strasburger's published views. The addition of subject-matter more suited to a text-book is also to be criticised, since it makes the work too long for a manual, without being full enough for a text. These liberties seem hardly justified by the translator's remark in the preface that "the curious in such matters can doubtless disinter them (the translator's additions) by a comparison of the first English edition (in which all such additions were in square brackets), and of the German third edition, with the present issue."

While the fact that the translation has reached a fifth edition indicates that there is a demand for Professor Strasburger's *Practicum* in English, we believe it would have been better to have presented simply a translation, with an appendix indicating English and American types which could be substituted for the German forms when the latter are inaccessible.—CHARLES J. CHAMBERLAIN.

Engler and Drude's "Vegetation der Erde."

THREE MORE VOLUMES of this most important series have appeared lately, making five volumes already issued.[4] The recent treatises are on the Caucasus region by Radde, on the Illyrian countries by Beck, and on the North German heath by Graebner. Radde's work[5] alone will be considered here, but early attention to the others may be expected. In the historical account one is surprised to see the immense number of botanists who have worked in the Caucasian region of Europe and Asia; one of the first was Tournefort in 1717, another was the Russian botanist Güllenstädt in 1787. More recently Ledebour, C. A. Meyer, Ruprecht, Trautvetter, Albow, Krassnow, and a host of others have made this region well known botanically. Radde himself has written a large number of botanical papers relating to Caucasia, having worked there since 1854.

The first chapter deals with the steppes, which are found in their perfection north of the Caucasus mountains. As elsewhere, the steppes of Caucasia are of very recent geological origin; the famous "black earth" is the characteristic soil. A large portion of the steppe region has been artificially deforested. As in America, grassy steppes pass gradually into Artemisia half-deserts, or into thickets like our chaparral (Paliurus maqui). Along the streams poplars and willows occur as on our prairies. Sand dunes and halophytic areas are present in some places, the latter especially near the Caspian sea. Where artemisias now occur, halophytes were once present; before them was the sea, and still further back fresh water lakes. Thus the

[4] BOT. GAZ. **26**: 356. 1898.

[5] RADDE, DR. GUSTAV, Grundzüge der Pflanzenverbreitung in den Kaukasusländern von der unteren Wolga über den Manytsch-Scheider bis zur Scheitelfläche Hocharmeniens. 8vo, pp. xii + 500, with 13 text figures, 7 heliogravures, and 3 maps. Leipzig: W. Engelmann. 1899.

life history of the Caspian region closely resembles that of our salt lake districts. On the mountain slopes the steppes pass rather rapidly into forests. The steppes are best developed near the Black sea, while the halophytes and artemisias are more abundant toward the Caspian sea. Smaller and similar steppes are found south of the Caucasus, paths of migration occurring along the Caspian shore.

The second and third chapters have to do with the luxuriant forests of Colchis near the shore of the Black sea, south of the Caucasus, and the similar forests of Talysch near the Caspian. These forests enjoy a mild maritime climate and are largely of the Mediterranean evergreen type (Schimper's sclerophyll forests), in which the cypress, laurel, olive, arbutus, ilex, etc., are abundant, as well as a few deciduous trees; conifers are scarce. Some species now endemic in Colchis were widespread before the ice age, so that Wettstein believes that this region was a prominent place of refuge in the Pleistocene. Conditions are similar in Talysch, except that conifers are wholly absent. Other Caucasian forests are described in the fourth chapter. Western Caucasia has more forests than the eastern part of the district, a consequence of climatic differences. Ascending the mountains, one sees the Paliurus maqui pass into true forests of deciduous trees and conifers like those of Europe. Higher up are great Rhododendron thickets.

Xerophytic rock plants are treated in the fifth chapter. The characteristic forms are Persian, such as Astragalus and Acantholimon, and decrease northwestward as the climate becomes moister. Lists of calcicoles and silicicoles are given, but Radde tends to minify their importance. The next chapter is concerned with the mountain floras, which reach a high development in Caucasia. The snow and timber lines are much lower in the west Caucasus region than farther east because of the high precipitation, but there is no difference between the north and south slopes. The subalpine regions have a dense vegetation, in which Rhododendron takes an important place. In the alpine regions plants are scattered, and at least two species complete their life cycle a thousand feet above the snow line. Sphagnum bogs are confined to the alpine regions. The last two chapters contain phenological data and a floristic subdivision of the Caucasian region.—H. C. COWLES.

NOTES FOR STUDENTS.

K. SHIBATA has made an extended study of the course of growth and of the changes which occur in the reserve food during the development of the shoots of the bamboo.[6] These observations supply many details in the knowledge of the life history of *Phyllostachys mitis* and the other species used for comparative study.—C. R. B.

A VERY READABLE account of statistical methods as applied in biology is

[6] Jour. Coll. Sci. Imp. Univ. Tōkyō **13**: 427–502. *pls. 22–24.* 1900.

given by Whitney.[7] He describes especially the curves and charts of Karl Pearson based on the theory of probability. Very suggestive advances are being made in the manner in which masses of data may be handled and expressed in simple form.— B. M. DAVIS.

HABERLANDT reports[8] that he has confirmed the observations of Němec[9] as to the existence of longitudinal fibrils in the protoplasm of plerome cells in Allium and Aspidium. He has identified these structures in living and in fixed tissues, but is not able to distinguish the sheath which Němec asserts to be present. He dissents, however, from the view that these are for the conduction of stimuli, and suggests that they serve rather for transport of plastic material.— C. R. B.

IN A THIRD PAPER on the proteolytic enzyme of Nepenthes,[10] Vines gives an abstract of the memoir of Clautriau[11] on digestion in the pitchers of these plants, and joins issue with him in various points. Vines holds "that the three enzymes, nepenthin, bromelin, and papain have essentially the same proteolytic action, which is tryptic," bromelin being most active, and nepenthin least. The latter also acts only in an acid medium; the others act best in a neutral one. Vines reiterates his former statement that all known proteolytic enzymes of plants are probably tryptic.— C. R. B.

THE ORIGIN of new species of plants has been recently treated from a botanical standpoint by von Wettstein.[12] He presents an extensive review of botanical literature bearing on Neo-Darwinian and Neo-Lamarckian theories, and concludes with a brief summary of his conclusions, the important points of which are as follows. High organization results from the fixing of adaptive characters by crossing and is largely modified by heterogeny; crossing and heterogeny play less important parts in the acquisition of adaptive characters; this stimulation comes through external factors, the plant having the ability to control its development by adaptation. It will be noted that this is a Neo-Lamarckian attitude.— B. M. DAVIS.

KUSANO[13] has recently made some extensive experiments on transpiration

[7] WHITNEY, Evolution and the theory of probability. Univ. Chron., Univ. of Cal. **3**: 402. 1900.

[8] HABERLANDT, G., Ueber fibrilläre Plasmastructuren. Ber. Deutsch. Bot. Gesells. **19**: 569–578. 29 Ja 1902.

[9] Die Reizleitung und die reizleitenden Strukturen bei den Pflanzen. Jena. 1901.

[10] Annals of Botany **15**: 563–473. 1901.

[11] La digestion dans les urnes de Nepenthes. Mém. couronnés, Acad. Roy. Belg. **59**: —. 1900.

[12] VON WETTSTEIN, Der gegenwärtige Stand unserer Kenntniss betreffend die Neubildung von Formen im Pflanzenreiche. Ber. Deutsch. Bot. Gesell. **18**: 184. 1900.

[13] KUSANO, Transpiration of evergreen trees in winter. Jour. Coll. Sci. Tōkyō **15**: 313–366. 1901.

of evergreen trees of Japan in winter. He found that the broad-leaved trees used in his experiments transpired per day 16.58^{gm} per 100^{gm} of fresh weight, and conifers 8.18^{gr}. The time of minimum transpiration agrees with that of minimum temperature, −5.9° C., and occurs at the end of January. These experiments, taken with those of Miyake,[14] who has shown that photosynthesis takes place without intermission in winter, seem to indicate that the abundance of evergreen trees in Japan is chiefly due to the favorable climate. The Puget sound region has a climate much like that of Japan, which may account for its great coniferous forests also.— H. N. WHITFORD.

STARCH FORMATION in Hydrodictyon is described by Timberlake.[15] There is no sharply differentiated chromatophore in this alga, the chlorophyll being distributed generally through the protoplasm between the plasma membrane and vacuolar membrane. The numerous pyrenoids are the centers of starch formation. Portions of the pyrenoids are cut off and changed directly into starch grains which lie in the surrounding protoplasm, arranged in such a manner as to show clearly their relation to the mother pyrenoid. The pyrenoid is then an active body contributing its substance to the starch grain. Kleb's distinction between pyrenoid and stroma starch in Hydrodictyon is not justified, for the latter are only older grains pushed away from the pyrenoids by the formation of younger starch. This study suggests interesting comparisons of other algal types with and without pyrenoids.— B. M. DAVIS.

AN ACCOUNT OF FERTILIZATION in another species of Pythium has appeared since the recent paper of Trow (Annals of Botany, Je 1901). Miyake[16] has investigated *Pythium Debaryanum*, and his results are essentially the same as those of Trow for *Pythium ultimum*. There is a mitosis in both oogonium and antheridium, the spindle being intranuclear as in Albugo. The contents of the oogonium becomes differentiated into ooplasm and periplasm, the nuclei taking position in the latter region. One nucleus enters the ooplasm from the periphery and becomes the functional female nucleus, those in the periplasm finally degenerating. There is no coenocentrum. A single male nucleus is discharged into the oogonium together with the greater part of the contents of the antheridium. Fusion of the sexual nuclei follows shortly. The investigation gives no data on the number of chromosomes in the various phases of the life-history.— B. M. DAVIS.

NOT LONG ago reference was made to the rather striking experiments of

[14] Bot. Centralb. **80**: 172.

[15] TIMBERLAKE, H. G., Starch formation in *Hydrodictyon utriculatum*. Annals of Botany **15**: 619–635. *pl. 34*. 1901.

[16] MIYAKE, K., The fertilization of *Pythium Debaryanum*. Annals of Botany **15**: 653–667. *pl. 36*. 1901.

Friedel,[17] who claimed that he had observed, apart from the living plant, the gas exchanges which are associated with photosynthesis. Macchiati[18] has discussed the significance of Friedel's results without adding many new facts of his own. Friedel[19] and Harroy[20] have repeated the earlier experiments of the former and obtained negative results. Friedel attributes this to the general weakening of synthetic processes in autumn, and promises to experiment on a large scale in the coming spring. He observed that young Pelargonium leaves show an activity in early summer that is twenty times that of similar young leaves in autumn, and that one scarcely ought to expect dead leaf material to exhibit gas exchanges at such an unfavorable period. Harroy, who repeated Friedel's experiments exactly and then improved upon the latter's experimental methods, concludes that Friedel's claim is premature, to say the least, though he admits its plausibility.— H. C. COWLES.

MITOSIS in the cells of Spirogyra presents difficulties that have led to a number of investigations with widely different results and much confusion. The last extensive paper on the subject is by Wisselingh.[21] The chief difficulties of the past have been the interpretation of nucleolus-like structures. Wisselingh finds generally one nucleolus for each nucleus, but sometimes two or more of varying sizes. Each has a membrane and contains a closely wound network, shown in certain stages of development to be made up of two long threads. The nucleolus of Spirogyra therefore shows many resemblances in structure to a nucleus. Outside of the nucleolus is a network filling the remainder of the nucleus.

There are two forms of mitosis, one with the formation of segments and one without. The segments are generally twelve in number, two coming from the nucleolus or two nucleoli, and the remainder from the nuclear network. These gather to form a nuclear plate at the metaphase of mitosis. Assuming that these segments are chromosomes, we then have in Spirogyra a form whose nucleoli are chromatic in character. However, the chemical nature of these bodies is not established, nor are all the stages of mitosis clearly explained.— B. M. DAVIS.

ITEMS OF TAXONOMIC INTEREST are as follows: R. CHODAT and E. WILCZEK (Bull. Herb. Boissier II. 2: 281–296. 1902) have begun a critical enumeration of the plants of the Argentine Republic collected by Wilczek.— R. CHODAT (*idem* 297–312), in continuing his *Plantae Hasslerianae* from Paraguay, describes numerous new species of Compositae.—J. CARDOT and I. THERIOT (The Bryologist 5: 13–16. 1902) have published some new and unrecorded mosses of North America.—E. L. GREENE (Ottawa Nat. 15: 278–282.

[17] BOT. GAZ. 32: 430. 1901.

[18] Bull. Soc. Bot. Ital. 1901: 323–335.

[19] Compt. Rend. 133: 840–841. 1901.

[20] Compt. Rend. 133: 890–891. 1901.

[21] WISSELINGH, Ueber Kerntheilung bei Spirogyra. II. Flora 87: 355. 1900.

1902) has described new species of Aster, Gnaphalium (2), and Arnica (4) from the northwest.— F. V. COVILLE (Proc. Biol. Soc. Washington **15**: 23–29. 1902) has discussed the confused synonymy of *Ribes aureum* and *R. lentum*.—C. L. POLLARD (Torreya **2**: 24–25. 1902) has described a new violet from New Jersey, and also (Proc. Biol. Soc. Washington **15**: 19–21. 1902) five new American species of Chamaecrista.— R. S. WILLIAMS (Bull. Torr. Bot. Club **29**: 66–68. *pls. 4–5*. 1902) has described new western species of Eurhynchium and Brachythecium.— CHARLES H. PECK (*idem* 69–74) has published thirteen new species of fungi.—ALICE EASTWOOD (*idem* 75–82. *pls. 6–7*) has described new Californian species of Fritillaria, Monotropa, Cycladenia, Potentilla, Orthocarpus, Spraguea, Sidalcea, Stachys, and Trifolium.— W. H. LONG, Jr. (*idem* 110–116) has described seven new Texan species of Puccinia, with illustrations. — F. GAGNEPAIN (Bull. Soc. Bot. France IV. **1**: session extraordinaire LXXIX. 1901) has published a new genus (*Aulotandra*) of Zingiberaceae.—J. M. C.

COWLES,[22] in a very comprehensive paper, gives the results of his observations on the influence of rocks on vegetation. The physical and chemical causes for different vegetation on different rocks is discussed. Attention is called to the facts that the resemblances, and not the differences, are the most striking, and that a number of factors have hitherto been neglected. Siliceous and calcareous rocks give rise to siliceous soils, so that there is more uniformity in the soils produced than in the rocks from which they were derived. The physiographic factor has also been neglected. No matter what the kind of rock, the ecological conditions will be much the same in the initial stages of erosion, and consequently the plants will be similar, while in the last stages of the life history the plants and conditions will be exactly the same. "The vegetation of all hills in a given region, of whatever chemical or physical nature, is tending toward an ultimate common destiny, which in most parts parts of the United States is the mesophytic forest. The succession of plant societies is sometimes slow and sometimes fast, and hence we have at any given period before the ultimate stage is reached a difference in soils. Were the stages equally rapid in all cases, there would be no such differences."

The author's researches comprise studies made on granites, gneisses, basalts, etc., in northern Michigan and in Connecticut, on quartzites in northern Michigan and in Montana, sandstones in northern Michigan, northern Illinois and in eastern Tennessee, shales in the Cumberland mountains of eastern Tennessee, and limestone and dolomites in Illinois, Wisconsin, Tennessee, and Montana.— H. N. WHITFORD.

[22] COWLES, H. C., Contributions from the Hull botanical laboratory. XXXIV. Bull. Am. Bureau Geog. **2**: 163–176, 376–388. 1901.

PROFESSOR HEGLER'S work on the Cyanophyceae[23] has been expected ever since 1895, but poor health delayed the investigation. After the author's death, the manuscript, quite ready for the press, was published by Professor G. Karsten, who states that after the appearance of A. Fischer's work the author most carefully re-examined the disputed points, but without deeming it necessary to change his views. The photomicrographs with which the paper is illustrated do but scant justice to the beautiful preparations which the reviewer had the privilege of examining. About forty pages are devoted to a critical review of the literature of the subject. The rest of the paper, about eighty pages, contains an account of Hegler's prolonged investigations. The principal conclusions are as follows. There are no naked protoplasts in the Cyanophyceae, all cells being provided with cell membranes, which in the heterocysts consist of cellulose, and in the other cells consist principally of chitin. In the protoplast, or cell contents, may be distinguished an outer color-containing layer and an inner colorless portion. The coloring matter is in the form of extremely small granules so closely crowded as to give the impression of an homogeneous color. The chlorophyll and phycocyan are contained in the same granules and these granules are to be regarded as the chromatophores of the Cyanophyceae. Starch or starch-like material is not present, but glycogen can be identified and is the first recognizable product of assimilation. Albuminoid crystals and slime vacuoles are never found in the colorless, central portion of the cell. The albuminoid crystals are particularly abundant in the heterocysts and spores, but are often entirely lacking in rapidly-growing vegetative cells.

Whether a nucleus is present or not is the most important morphological question in connection with the Cyanophyceae and bacteria, since these are the only organisms in which a nucleus has not been positively identified. The bearing of this question upon present morphological theories of heredity is evident. Since previous methods have failed to solve the problem, the author devoted much attention to fixing and staining, and recommends the following: Saturated aqueous solution of SO^2, 7 parts; 94 per cent. alcohol, 93 parts; mix just before using and fix for 12–24 hours; wash with alcohol. Another fixing agent that gives good results is: 40 per cent. formalin, 5 parts; 94 per cent. alcohol, 95 parts; wash in 50 per cent. alcohol. The first-named fixing agent, however, allows a sharper staining of the nuclear figures. Fuchsin, safranin, and gentian-violet do not stain well; iodine-green and methyl-blue are better. The following method gave the best results: crystals of ammonia alum, 75 parts; water, 750 parts; dissolve the crystals in water, and add glycerin 125 parts, 94 per cent. alcohol 100 parts, and saturated alcoholic solution of haematoxylin 25 parts.

[23] HEGLER, ROBERT, Untersuchungen über die Organization der Phycochromaceenzelle. Jahrb. Wiss. Bot. **36**: 229–254. *pls. 5–6.* 1901.

The solution must stand for several weeks in a beaker, covered only by a piece of filter paper, before it is ready for use. Then stain for 24 hours in a mixture of 10 parts of the above solution in 100 parts of a 1 per cent. aqueous solution of formalin. Wash in running water at least one hour and then differentiate in saturated alcoholic solution of picric acid 1 part, water 1 part, and 94 per cent. alcohol 2 parts. The differentiation will generally require only a few seconds. Rinse in 75 per cent. alcohol and examine. If still too deeply stained transfer again to the differentiating solution and so continue until the stain is clear and sharp, then wash in running water for an hour, transfer to 50, 75, 94 per cent., and absolute alcohol, clear in toluol and mount in dammar.

From such preparations the following conclusions are drawn. The Centralkörper, or central body of the Cyanophyceae, is a nucleus. The most important reason for this conclusion is the behavior of the central body during cell division. In all cells of the Cyanophyceae, except the heterocysts, the nuclei of which degenerate very early, a single nucleus is present, its form depending largely upon the shape of the cell. The resting nucleus consists of a slightly staining ground mass in which are imbedded numerous, deeply staining granules. These granules from their behavior during division, their reaction to stains and digestive fluids, are to be identified with the chromatin granules of higher plants. They are not the "red granules" of Bütschli. The nucleus differs from that of higher plants in not possessing a nucleolus or nuclear membrane. During nuclear division the granules fuse into chromosomes which separate as division proceeds. Strands which represent spindle fibers may be seen between the separating groups. The wall first appears as a ring midway between the daughter nuclei and gradually grows toward the center until the partition is complete. The writer believes that he has shown positively that the Centralkörper is to be identified with the nucleus of higher plants.

It is interesting to note that Zacharias, in a lengthy and somewhat prejudiced review of Hegler's paper (Bot. Zeit. **59**: 322–327. 1901) disputes the accuracy of these conclusions and insists that there is no nucleus in the Cyanophyceae.—CHARLES J. CHAMBERLAIN.

NEWS.

PROFESSOR VOLNEY M. SPALDING, of the University of Michigan, is doing botanical work in Florida.—*Science.*

GEO. H. SHULL, recently of the University of Chicago, has received an appointment as assistant in the U. S. National Herbarium.

MRS. MARY L. PULSIFER AMES, the well-known Californian botanist, died March 20, at her home in San Jose, California, at the age of 57.

MR. ELMER D. MERRILL, assistant in agrostology in the U. S. Department of Agriculture, has accepted an appointment in the Philippines.

FRANK MARION ANDREWS (University of Indiana) recently received his doctorate from the University of Leipzig, with the grade *summa cum laude.*

PROFESSOR CHARLES R. BARNES sailed for Europe March 22, to be absent nine months, during which time he will visit the principal botanical laboratories.

DR. K. VON TUBEUF, chief of the biological division, the German Department of Health, has been appointed professor of forestry in the University of Munich.—*Science.*

DR. MAX KOERNICKE, Privat Docent in botany, in the University of Bonn, has received an additional appointment as Privat Docent in the Landwirtschaftlichen Akademie of Bonn-Poppelsdorf.

PROFESSOR BESSEY, of the University of Nebraska, is to give a course of twenty lectures on botany in the Colorado Springs Summer School, which is to be held in Colorado Springs, Colo., in July and Angust.—*Science.*

PROFESSOR W. H. BREWER, the well-known professor of Agriculture in the Sheffield Scientific School of Yale University, will retire from the active duties of his position at the end of the present academic year, after a service of thirty-seven years.

W. J. SPILLMAN, agriculturist of the Washington Agricultural College and Experiment Station at Pullman, has succeeded F. Lamson-Scribner as agrostologist in the Department of Agriculture, Washington, D. C. Mr. Scribner sailed February 23 for Manila.

AT THE BIOLOGICAL LABORATORY at Cold Spring Harbor the following courses in botany are offered for the summer of 1902: *Cryptogamic botany*, by Dr. D. S. Johnson, Johns Hopkins University; *Ecology*, by Samuel M. Coulter, Washington University; and *Bacteriology*, by Nelson F. Davis, Bucknell University.

THE FIFTY-FIRST MEETING of the *American Association for the Advancement of Science* will be held at Pittsburg, from June 28 to July 3. It is to be hoped that botanists will keep this meeting in mind, as it promises to be one of unusual interest in connection with the great meeting of scientific bodies to occur at Washington during the next Christmas holidays.

THE BRYOLOGIST has become a bi-monthly journal, and now includes not merely popular articles, but also technical papers. The features of the current year are a series of notes on nomenclature by Mrs. E. G. Britton; a continuation of the illustrated series on the lichens by Mrs. Harris; and of the liverworts by Mr. Barbour; and descriptions and illustrations of new and rare mosses. The editorial address is Mrs. Annie Morrill Smith, 78 Orange street, Brooklyn, N. Y.

THE BOTANICAL COURSES offered at Woods Hole during the summer of 1902 include cryptogamic botany, ecology, plant physiology, and plant cytology. The instructors are Drs. Davis, Moore, True, and Cowles, Professors C. H. Shaw and A. C. Moore, Mr. J. J. Wolfe, and Miss McRae. A more complete organization of the botanical supply department offers employment to a limited number of students who may thereby cover the tuition fees. Inquiries should be addressed to Dr. B. M. Davis, The University of Chicago.

IN *Science* for February 28[1] Dr. H. H. Field makes the welcome announcement that, in coöperation with the *Association Internationale des Botanistes*, the *Concilium Bibliographicum* will undertake the issue of a botanical bibliography on cards similar to those issued for several years in zoölogical lines. Two Zürich botanists, Dr. Stephen Bruneis and Mr. Emil Schoch-Etzensperger, have already been appointed to organize the work. Publication will begin in 1903. Botanists will await further announcements with interest. Every one is asked to add to his mailing list for separates the *Concilium Bibliographicum, Zürich-Neumünster, Switzerland.*

THE PART of the twenty-first annual report of the United States Geological Survey dealing with the Forest Reserves, to be published soon, will contain reports of the Lewis and Clarke forest reserves of Montana, the Mount Rainier and the Olympic forest reserves of Washington, the Cascade range forest reserve of Oregon, the Lake Tahoe and the Stanislaus reserves of California. The report also includes classification of timber lands in parts of California and Indian Territory, and a discussion of timber conditions in the pine region of Minnesota. The reports as a rule contain descriptions of the topography, the amount and distribution of timber, and the effect of fires and grazing on the forests.

[1] N. S. 15:357. 1902.